TO: Tara Smith
FROM: Michael Mierzwa
DATE: August 26, 2001
RE: Delta Wetlands Preliminary DSM2 Studies

1. Introduction

Delta Wetlands proposes to convert two Delta islands, Bacon Island and Webb Tract, into reservoirs. Both islands would be used to store water during surplus flow periods. Later this water would be released for export enhancement or to meet Delta flow/water quality requirements.

This study uses the DWRSIM 771 existing condition hydrology as the input for a series of DSM2-HYDRO and QUAL 16-year planning studies. This study ran from 1975 – 1991. This hydrology was used by Jones and Stokes in their analysis for Delta Wetlands and is the basis of the Delta Wetlands Environmental Impact Report (EIR). This study is based on the most recent version of the DSM2 geometry, and also makes use of QUAL's ability to model multiple water quality constituents. In addition to the traditional EC modeling, QUAL was used to simulate dissolved organic carbon (DOC) and ultraviolet absorbance at 254 nm (UVA) impacts due to the operation of the two island reservoirs.

This report includes the descriptions of the two scenarios (a base case and an alternative based on the Delta Wetlands project) and the results of these DSM2 simulations at M&I locations. The operation (flow into and out of the island reservoirs) was provided by David Forkel of Delta Wetlands (2001a). The physical specification for the Delta Wetland islands is based on the Delta Wetlands EIR. A brief discussion of the DWR-Municipal Water Quality Investigations (MWQI) data that were used as the boundary conditions for the QUAL DOC and UVA simulations is also provided.

2. Description of Scenarios

The two different scenarios were based on the DWRSIM 771 existing condition hydrology. The base case simulated the Delta without the operations of the proposed Delta Wetlands project. The Delta Wetlands alternative included the proposed operations of Bacon Island and Webb Tract, but did not account for the changes in land use of the two proposed habitat islands. Brief summaries of both scenarios are described below in Table 1, followed by more detailed descriptions of these assumptions.

Table 1: Summary of Planning Scenarios.

	Base: No Action	*Alternative: Delta Wetlands Operations*
Project Islands	No.	Yes. (Bacon Island and Webb Tract.)
Habitat Islands	No.	No.
Boundary Flows	DWRSIM 771.	DWRSIM 771.
Boundary Stage	25-hour Repeating Tide.	25-hour Repeating Tide.
Martinez EC	ANN w/ Net Delta Outflow.	ANN w/ modified Net Delta Outflow.
Rim Boundary EC	DWRSIM 771.	DWRSIM 771.
Island Diversions	Historical DICU.	Modified DICU.
Island Return Flows	Historical DICU.	Modified DICU.
Island Seepage	Historical DICU.	Historical DICU.
Martinez Boundary DOC / UVA	N/A	N/A
Rim Boundary DOC / UVA	MWQI data.	MWQI data.
Island EC	Historical DICU.	Historical DICU. DSM2 mixed and stored EC in Project reservoirs.
Island DOC / UVA	MWQI data.	MWQI data. Three bookend measurements for Project reservoirs.

2.1. No Action (Base Case):

The DWRSIM 771 existing conditions study was used to provide the rim boundary flows and exports. Gate and barrier configurations were designed to account for the proposed operation schedule for the South Delta Permanent Barriers (which include Old River at Head, Old River at Tracy, Middle River, and Grant Line Canal). The Suisun Marsh Salinity Control Gate and Clifton Court Forebay Gates were both operated according to previous DSM2 planning studies that used the DWRSIM 771 existing conditions study as a base case.

Historical DSM2 Delta Island Consumptive Use (DICU) data were used for all the HYDRO simulations and the QUAL EC simulation. Martinez EC data were generated using an artificial neural network (ANN) and Net Delta Outflow. DWR-MWQI observations were used to create synthetic time series for DOC and UVA (see Section 3.6) at the following rim boundaries: San Joaquin River, Sacramento River, and the Eastside streams. The flux of DOC and UVA from the downstream boundary at Martinez (the sea) was considered insignificant. Details on the development of agricultural return DOC and UVA data for DSM2 based on the MWQI observations is described in the report *Revision of Representative Delta Island Return Flow Quality for DSM2 and DICU Model Runs* (Dec. 2000) as prepared by Marvin Jung and Associates, Inc.

2.2. Delta Wetlands Operation (Alternative 1):

Jones and Stokes used the DWRSIM 771 existing conditions study to create a preliminary schedule of diversions into and releases out of the two proposed Delta Wetlands islands. This schedule did not separate the storage, diversions, and releases between the two islands; however, a simple operating rule was proposed to govern the independent operation of the islands. This proposed set of rules is listed below in Table 2.

Table 2: Proposed Rules of Operation.

Filling (Diversions to Islands)	Fill Bacon Island first, then fill Webb Tract.
Emptying (Releases from Islands)	Empty Bacon Island first, then empty Webb Tract.

Using the above operation rules and the target monthly storage for the project reservoirs provided by Jones and Stokes, the diversions and releases for each island as well as each pump were separated for use in DSM2-HYDRO. The result of these operation rules is that each island fills and empties at different times and for different amounts. The combined diversions for both pumps at each island are shown below in Figure 1. The releases for each island are shown below in Figure 2. The process by which these diversions and releases were calculated is further explained in Appendix A.

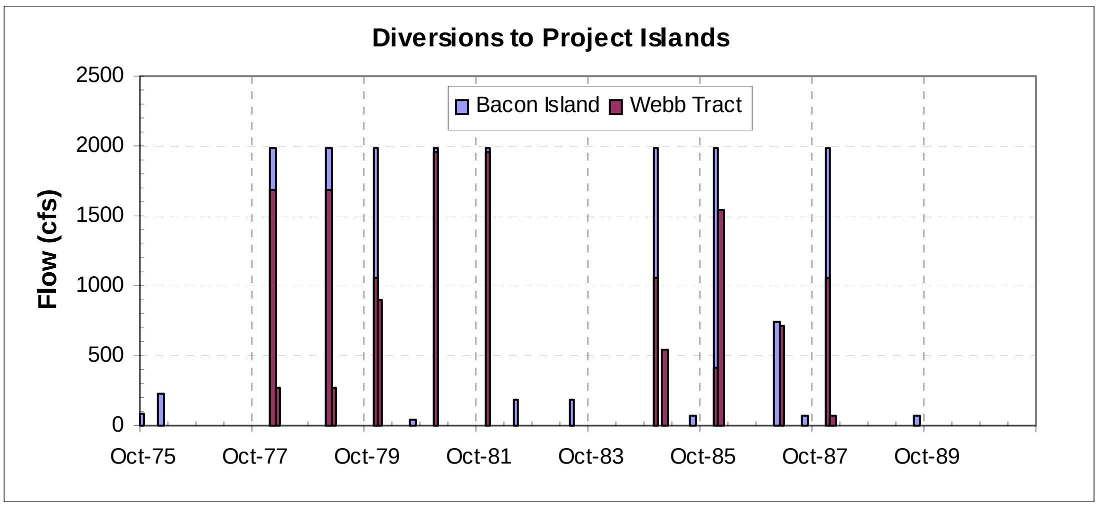

Figure 1: Diversions to Delta Wetlands.

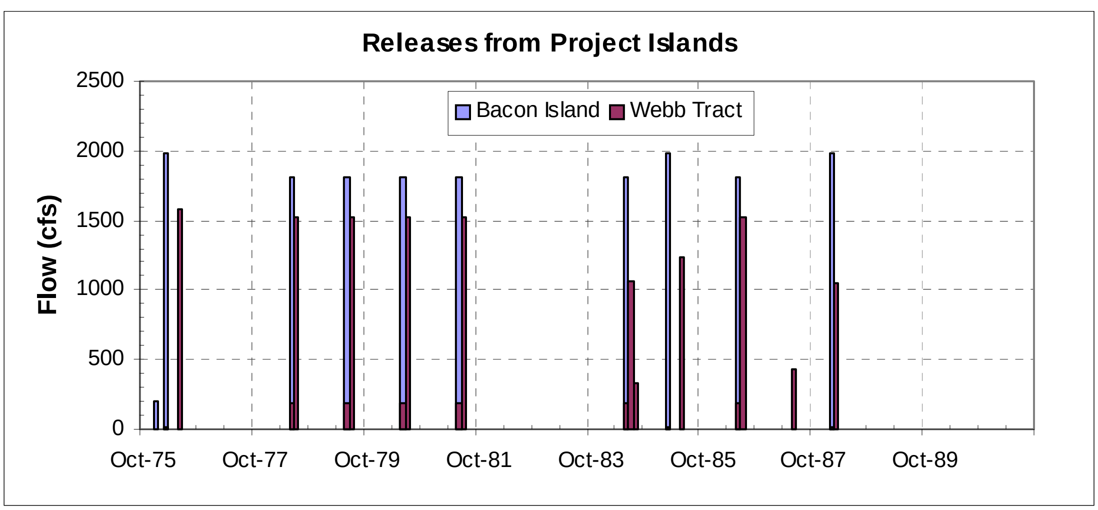

Figure 2: Releases from Delta Wetlands.

The configuration of the project islands as modeled by DSM2 is listed in Table 3. The storage capacity, discharge location, and both intake locations for the project islands determined from the Delta Wetlands EIR.[1] The locations are shown in Figures 3 and 4. According to the operations EIR schedule, water was typically diverted into the islands in the winter on the northern ends of the islands and released back into the Delta in the summer on the southern ends of the islands.

Table 3: DSM2 configuration of Delta Wetlands project islands.

Island	*Storage Capacity (TAF)*	*Discharge Location (Node)*	*Intake Location #1 (Node)*	*Intake Location #2 (Node)*
Bacon Island	120	213	98	128
Webb Tract	118	224	40	103

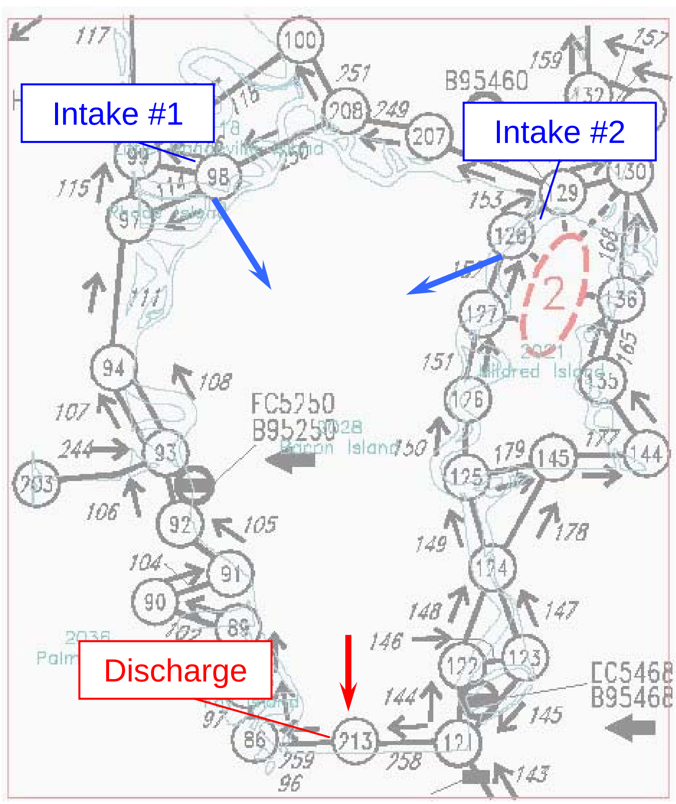

Figure 3: DSM2 Representation of Bacon Island.

[1] The Bacon Island discharge location (node 213) is based on a location determined from a draft EIR from early 2000. This location has been moved to the Middle River in the current EIR. By moving the Bacon Island discharge location away from the Old River, it is expected that the water quality impacts from Bacon Island releases will be reduced at both the Contra Costa Old River and Los Vaqueros intakes. Future DSM2 studies will model the Bacon Island location at a point consistent with the current EIR.

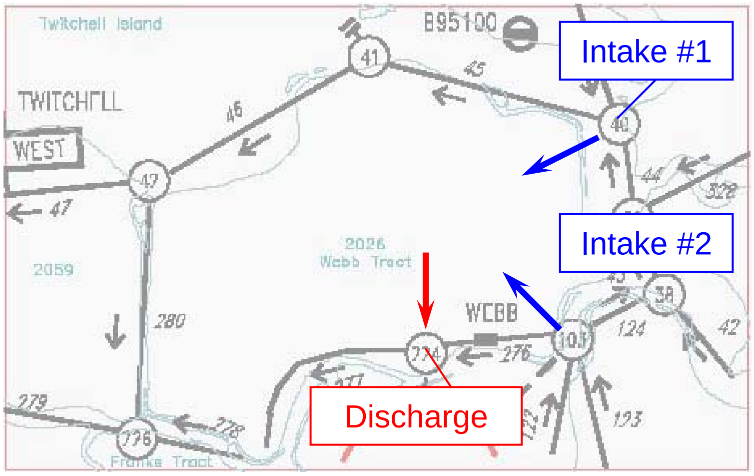

Figure 4: DSM2 Representation of Webb Tract.

The volume of water stored in each island reservoir is a direct function of the amount of water diverted into or released from each island. Volume of a reservoir in DSM2 is the product of the reservoir's surface area and its current stage level. The project island reservoirs were isolated from the Delta channels, thus there was no limit to the stage in either reservoir. In order to prevent drying up of the island reservoirs 5 ft of water was assumed to be present on both islands at the beginning of the simulation.[2] This water was considered dead storage and was never released into the Delta. Although the initial concentration of this dead storage is 0 umhos/cm, inchannel water was diverted into Bacon Island and later released several times during the DSM2 spin-up period in 1974 and 1975. Through this activity the dead storage EC concentration in Bacon Island was 161 umhos/cm at the start of the DSM2 simulation.

Water quality from the two Delta Wetland island reservoirs was modeled two different ways using DSM2. These two different approaches are described below.

For the QUAL EC simulations the reservoirs were isolated from the Delta channels as described above and flow between the surrounding channels and the project islands were regulated in DSM2 by a direct "object-to-object" transfer. When water was diverted into the islands, this object-to-object transfer moved water from both of the intake nodes for the islands being filled into the reservoir. This process was reversed in accordance with the release schedule except that water was then discharged at the discharge locations listed in Table 3.

This process allowed QUAL to automatically mix incoming EC concentrations from the nearby channels with the EC already present in the reservoirs; thus the water released from the reservoirs would better represent the mixed water quality of the water stored in the reservoirs. The EC concentrations of the island reservoirs only changed when new

[2] The choice of 5 ft of depth was chosen as a preliminary starting depth in the EC simulations in order to prevent DSM2 from drying up. DSM2 does not support the wetting and drying of channels or reservoirs. Future DSM2 studies will use a smaller depth for the reservoir dead storage.

water was transferred into the islands, not when water exited the islands. This process is described in greater detail in Section 4.1.

For the QUAL DOC and UVA simulations, these preliminary studies were designed to investigate the impact of different DOC and UVA "bookend" measurements. Instead of using active reservoirs, diversions to the islands were treated as sinks located at the two intake nodes for each island and the releases from the islands were treated as sources located at the discharge locations. Water released back into the Delta through the discharge nodes was given a fixed DOC or UVA concentration depending upon the scenario. A list of DOC and UVA values for both islands is listed below in Table 4.

Table 4: Summary of DOC and UVA Delta Wetlands Operations Values.

Bookend Simulation	***DOC (mg/L)***	***UVA (cm^{-1})***
Low	6	0.289
Middle	15	0.686
High	30	1.348

The UVA measurements were based on the DOC concentrations, using the relation developed in the *Revision of Representative Delta Island Return Flow Quality for DSM2 and DICU Model Run* report (see Equation 1).

$$UVA = 0.02374 + 0.04415 \times DOC \qquad \text{[Eqn. 1]}$$

With changes in the land use of the project islands, the diversions and return flows for Bacon Island and Webb Tract were modified using the Delta Island Consumptive Use (DICU) model. DICU computes the consumptive use at each node in DSM2 based on the historical needs for each island or water habitat in the Delta. The diversions and return flows for each island are distributed to different nodes, such that the modeled diversions, return flows, and/or seepage at any one node frequently include the individual contributions from different islands. The contributions from Bacon Island and Webb Tract were removed from all of the nodes surrounding both islands (see Figures 3 and 4). DSM2 mixes return flows with fixed "drainage" water quality measurements at each node. Even though the contributions from the project islands were removed from the intake and release nodes, the diversions and return flows from the neighboring islands could mix with the measurements coming from the island reservoirs. In order to prevent DSM2 from mixing the return flows from these neighboring islands with the fixed bookend concentrations, the diversions and return flows from other islands were relocated from the intake and pump locations listed in Table 3 to nearby nodes.

Since seepage in DSM2 represents the amount of water that comes from the Delta channels to the islands, it was not modified for either scenario.

3. Simulation Inputs

3.1. Delta Cross Channel

The position of the Delta Cross Channel was predetermined by the DWRSIM 771 existing conditions study. For most years, the Delta Cross Channel was closed except during the summer months Jun. – Sep. when flow at Freeport (as modeled by DWRSIM) was less than 23,000 cfs. In some wet years, such as 1982 and 1983 the Delta Cross Channel was also closed during some of these months due to high flow conditions.

3.2. Flow

Rim flows, exports, and diversions not covered above in the description of the Delta Wetlands Operation came from the DWRSIM 771 existing conditions study. The rim flows include the Sacramento River, San Joaquin River, and the Yolo Bypass and then a combined parameter representing the eastside flows into the Delta. Exports include the State Water Project (SWP), the Central Valley Project (CVP), Vallejo diversions, North Bay Aqueduct diversions, and Contra Costa Canal diversions from Rock Slough. Contra Costa operations on the Old River for the Los Vaqueros reservoir were not available at the time this study was conducted.

The combined SWP and CVP exports are shown in Figure 5 (below) in order to provide a general feel for the amount of water that would be flowing south through the Central Delta over the study period.

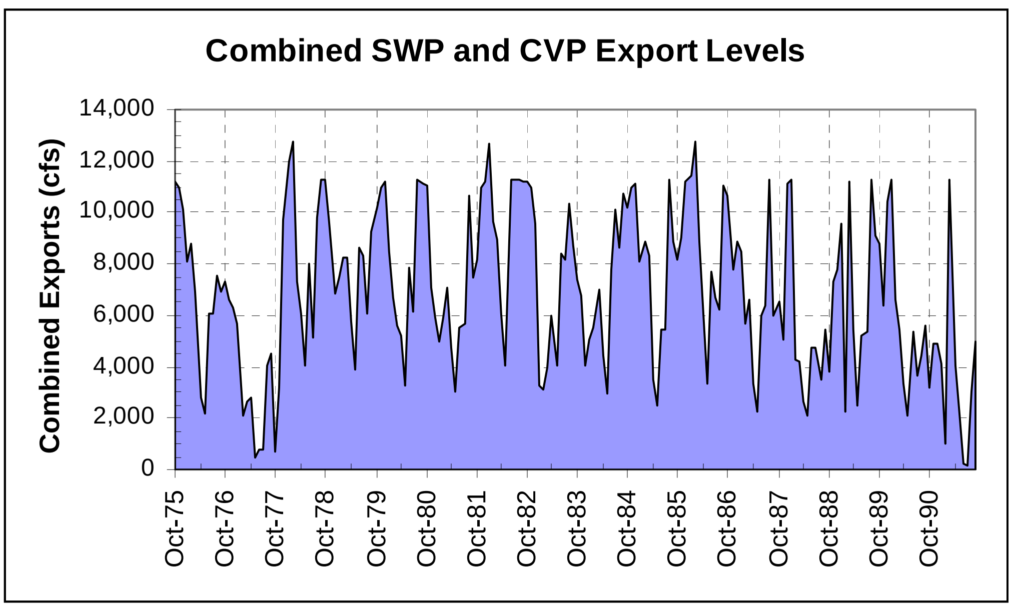

Figure 5: Combined SWP and CVP Export Levels.

3.3. Stage

A repeating tide was used as the downstream boundary condition at Martinez. This tide includes flood / ebb variations, but does not include Spring / Neap variations.

3.4. South Delta Permanent Gates

The proposed future operation of the four South Delta fish and agricultural permanent gates, Old River at Head, Old River at Tracy, Middle River, and Grant Line Canal barriers, was used in this study. When operating, the gates only allowed flow in the upstream direction. Each structure is either installed or removed during one of 13 planning periods, see Figure 6 below. Each month represents one planning period, with the exception of April, which is divided into two planning periods. This was done so the gates could be installed in the middle of the month, per the proposed future operation of the gates.

Barrier	***Oct***	***Nov***	***Dec***	***Jan***	***Feb***	***Mar***	***Apr***	***May***	***Jun***	***Jul***	***Aug***	***Sep***
Old River @ Head												
Old River @ Tracy												
Middle River												
Grant Line Canal												

Figure 6: Schedule of Permanent Barrier Operations.

3.5. Other Gates

The Suisun Marsh Salinity Control Gate was operated October through May of each year. The Clifton Court Forebay Gates were operated based on a schedule created for prior DSM2 planning runs that used the same DWRSIM 771 study as input. The Forebay Gate schedule would open the gates at different times based on one of three priorities. These priorities optimize the intake of water into the Forebay while offering increasing levels of protection to the water levels in the South Delta. A complete description of these priorities and their implementation in DSM2 can be found in *Status Report on Technical Studies for CALFED Water Management Planning* (Jul. 1999).

3.6. Quality

Water quality inputs were applied both at the external boundaries and at Delta interior locations through Delta Island Consumptive Use (DICU). The sources and nature of these data are discussed below.

3.6.1. EC

As discussed above in the description of the base case, the Martinez downstream boundary EC was generated using an ANN with Net Delta Outflow as the input. Kristof coefficients were used to convert daily EC into hourly values for use in QUAL.

The rim flow boundaries for the Sacramento River, Yolo Bypass, and eastside streams were all given fixed EC concentrations of 125, 150, and 125 umhos/cm respectively.

Standard DICU data developed from DWR Delta Modeling's DICU model were used to represent the quality of water draining off the Delta islands. For the base case all of the standard DICU node locations were used. For the alternate scenario some of the nodes surrounding Bacon Island and Webb Tract were modified (see section 2.2 for a detailed description of how this was done) in order to account for the change in use of these two islands.

3.6.2. DOC

Based on monthly dissolved organic carbon observations from DWR MWQI, time series of monthly average DOC were created for the Sacramento River, San Joaquin River, and eastside streams (see Figure 7). The Sacramento River data were based on Green's Landing observations. Vernalis observations were used for the San Joaquin River data. The eastside stream data were based on American River observations. These three time series were applied as the boundary conditions. It was assumed that the amount of DOC at the downstream Martinez boundary was negligible.

Bookend values were used to represent the DOC coming off the project islands. Table 5 (located above) summarizes these bookends.

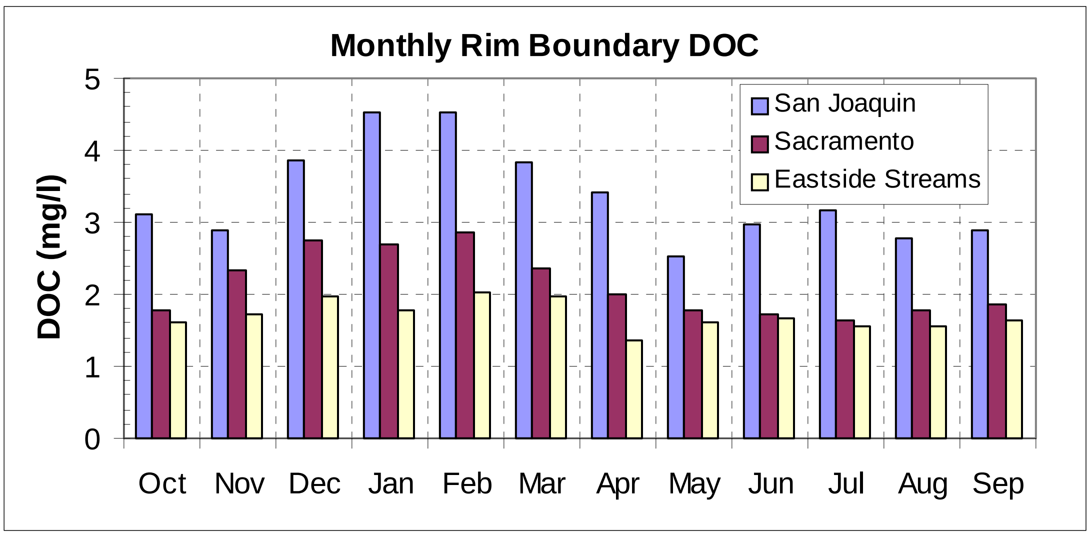

Figure 7: Monthly Averaged DOC Boundary Conditions.

DICU data developed as part of the DWR MWQI studies were used to represent the DOC (mg/l) draining off the Delta islands (see Jung, 2000). Three different ranges of DOC returns were used in the DOC DICU data. Figure 8 represents the DOC values as modeled in DSM2 for the three different ranges. As illustrated in Figure 8, high range DOC is associated with DOC releases that peak out above 30 mg/l. Similarly, the low range DOC is used for islands that were found to have low DOC releases. For the base case, all of the historic DICU agricultural diversions and return flows were used. Some of the agricultural diversions and return flows in the alternate scenario were modified as described in Section 2.2.

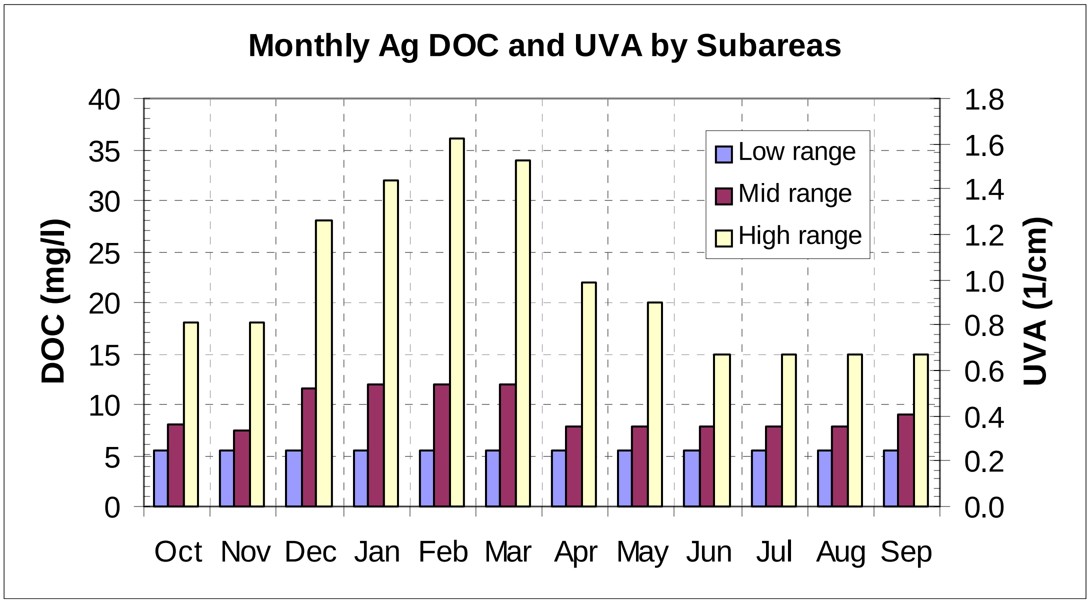

Figure 8: Monthly Averaged DOC and UVA from Agricultural Returns.

3.6.3. UVA

Based on monthly UVA-254 observations from DWR MWQI, time series of monthly average UVA were created for the Sacramento River, San Joaquin River, and eastside streams (see Figure 9). These three time series were applied as the boundary conditions. Again, the UVA-254 value at the downstream Martinez boundary was considered negligible.

Bookend values were used to represent the UVA coming off the project islands. Table 5 (located above) summarizes these bookends. These bookends were calculated using the relationship (Equation 1) described in Section 2.2 developed by Jung.

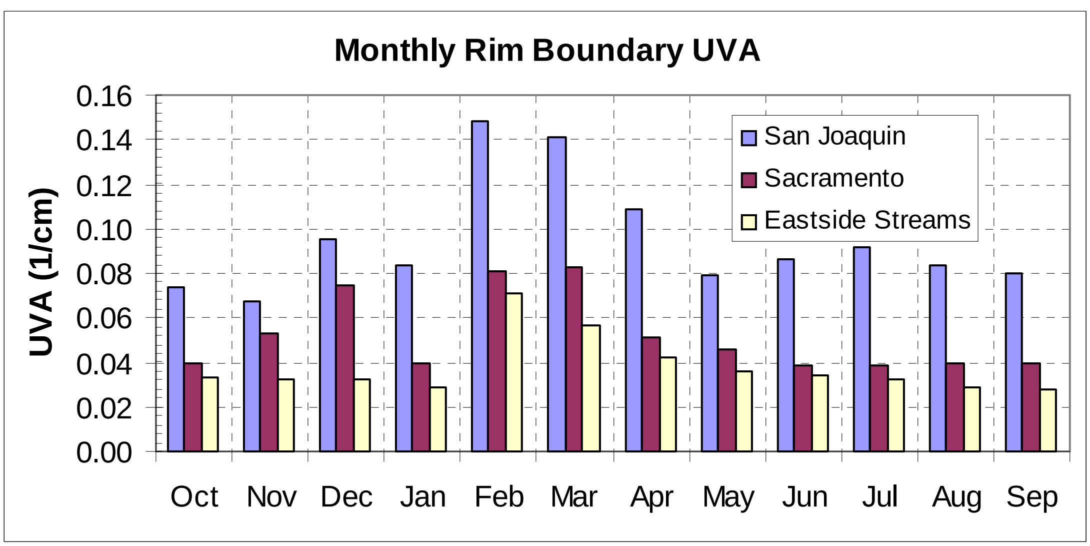

Figure 9: Monthly Averaged UVA Boundary Conditions.

DICU data developed as part of the DWR MWQI studies were used to represent the water quality draining off the Delta islands (see Jung, 2000). Three different ranges of UVA returns were used in the UVA DICU data. The values of these ranges are illustrated in Figure 8. The values were calculated by converting DOC to UVA using Equation 1. For the base case, all of the standard DICU agricultural diversions and return flows were used. Some of the agricultural diversions and return flows in the alternate scenario were modified as described in Section 2.2.

3.6.4. Initial Conditions (Cold Start)

DSM2 planning studies cover a 16-year period from Oct. 1975 to Sep. 1991. Unlike HYDRO, QUAL requires a much longer start-up period. In the case of planning studies, no assumption is made about the initial water quality conditions in the Delta; thus an extra year is run in order to simulate the mixing of the delta. This is called a cold start routine. Both HYDRO and QUAL are run for this extra year, but the results are disregarded during this cold start period.

4. Results

This report discusses three water quality constituents, electrical conductivity (EC), dissolved organic carbons (DOC), and ultraviolet absorbance at 254 nm (UVA).

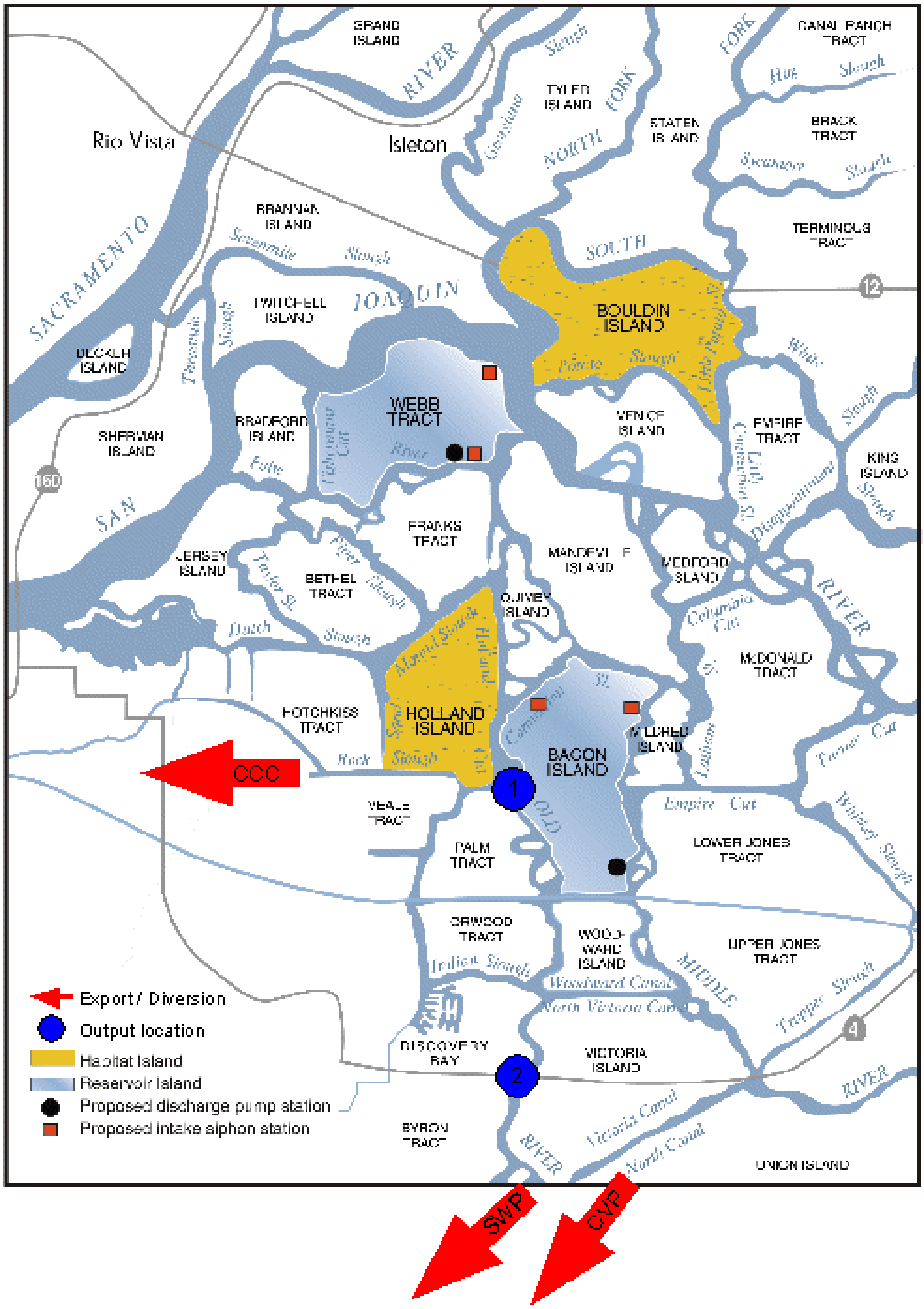

Figure 10: Location of Delta Wetland Project Islands and Output Locations.

Modeled water quality at four export / diversion facilities are shown below for the entire planning period (1975 – 1991): Contra Costa's Rock Slough intake near the Old River, Contra Costa's Los Vaqueros intake on the Old River, the SWP and CVP intakes at Banks and Tracy. The actual output locations for Contra Costa's Rock Slough (location

#1) and Contra Costa's Los Vaqueros (location #2) intakes were along the Old River, as are shown above in Figure 10. [NOTE: The habitat islands shown in Figure 10 were treated as normal Delta islands in DSM2.]

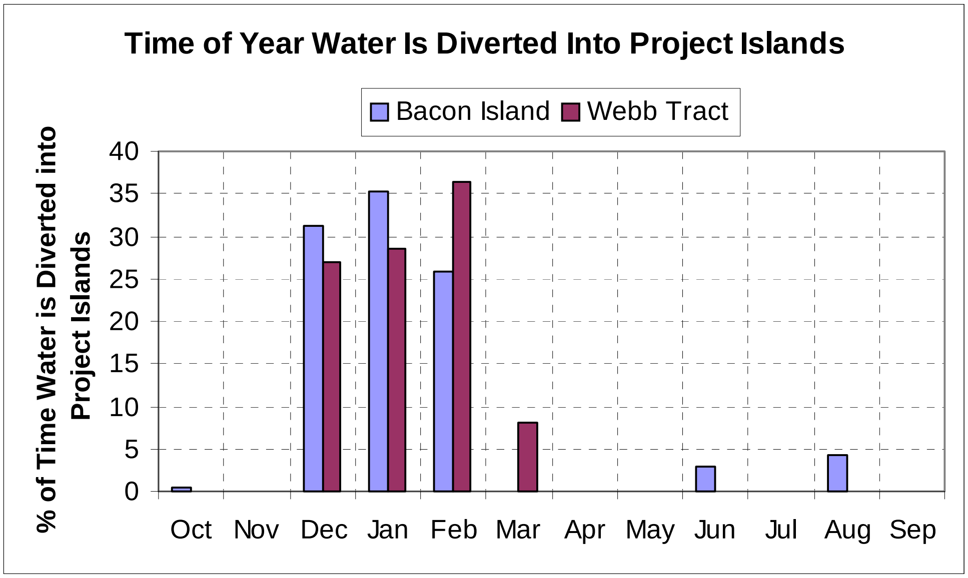

Figure 11: Time of Year Water is Diverted to Project Islands.

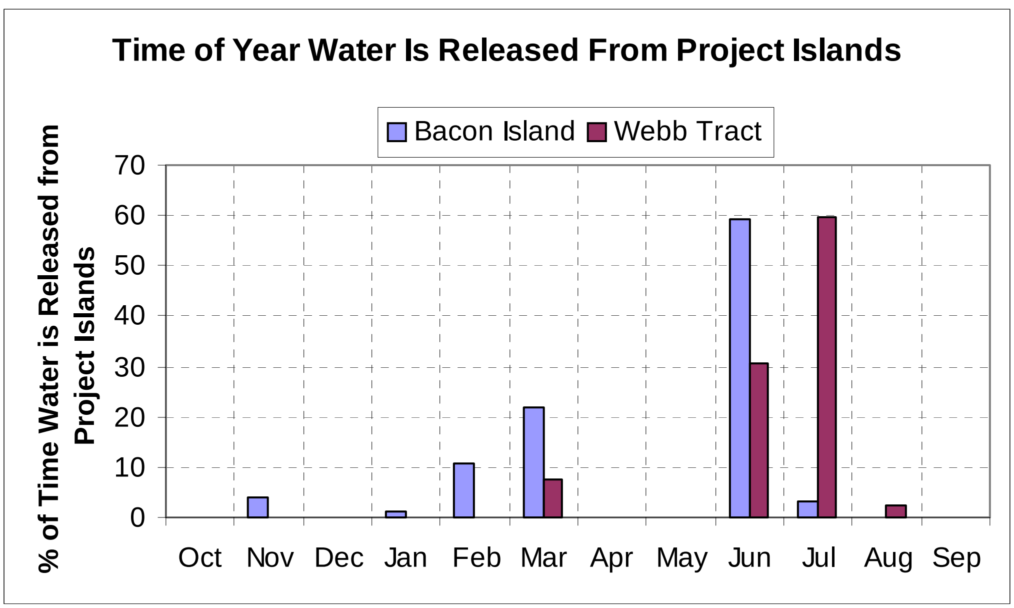

Figure 12: Time of Year Water is Released from Project Islands.

The percentage of the time of year water was diverted to and later released from the project islands for the entire study period is shown in Figures 11 and 12. Generally the islands were filled in the winter months (Dec., Jan., and Feb.) and emptied in the summer months (Jun. and Jul.). The timing of the combined SWP and CVP exports were determined by the DWRSIM 771 study and are shown in Figure 5.

4.1. EC

As described above in Table 3 (see Section 2.2), two reservoirs were created to simulate EC coming from the two project islands: Bacon Island and Webb Tract. These reservoirs were connected to the Delta in DSM2 by using object to object transfers. This technique controlled when water would be added to or removed from the reservoirs. It also allowed for the intake points to be separated from the discharge location.

Since the water quality of the reservoir islands is a function of the water quality around the intakes and the current water quality in each island reservoir, QUAL was able to store the water and account for changes in water quality due to mixing, as shown in Equation 2. The only time water quality in the islands would change was when water was added, which can be seen in Figures 13 and 14.

$$C_{new} = \frac{C_{\inf lows} V_{\inf lows} + C_{island} V_{island}}{V_{\inf lows} + V_{island}} \qquad \text{[Eqn. 2]}$$

If the EC concentration of the water at the intakes was lower than the EC levels inside the island reservoir, then the inflows would reduce the island EC concentration. If the EC concentration of the water at the intakes was higher than then the EC levels inside the island, then the inflows would increase the island EC concentration.

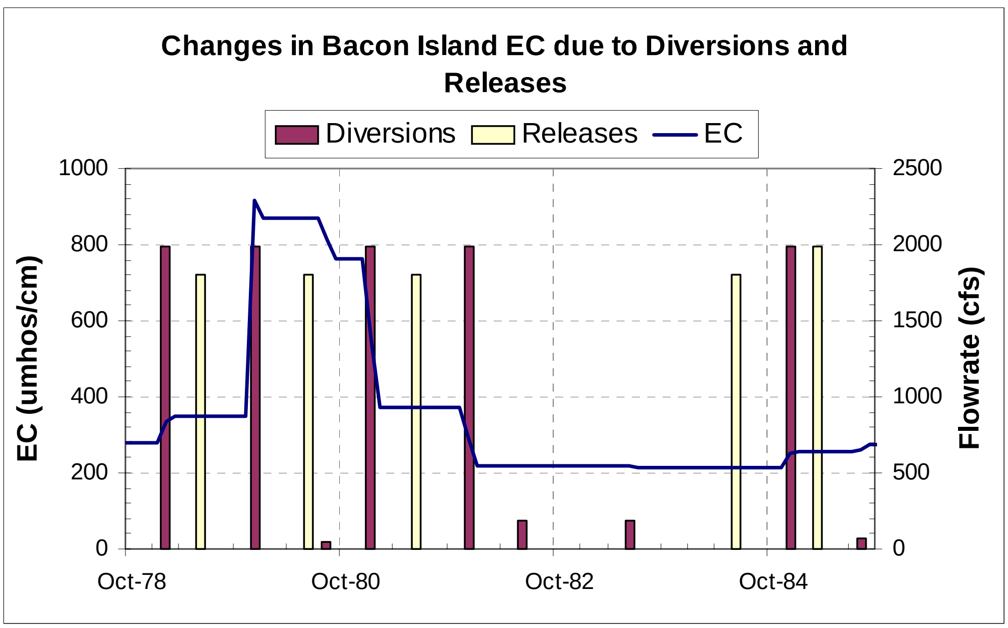

Figure 13: EC (umhos/cm) in Bacon Island.

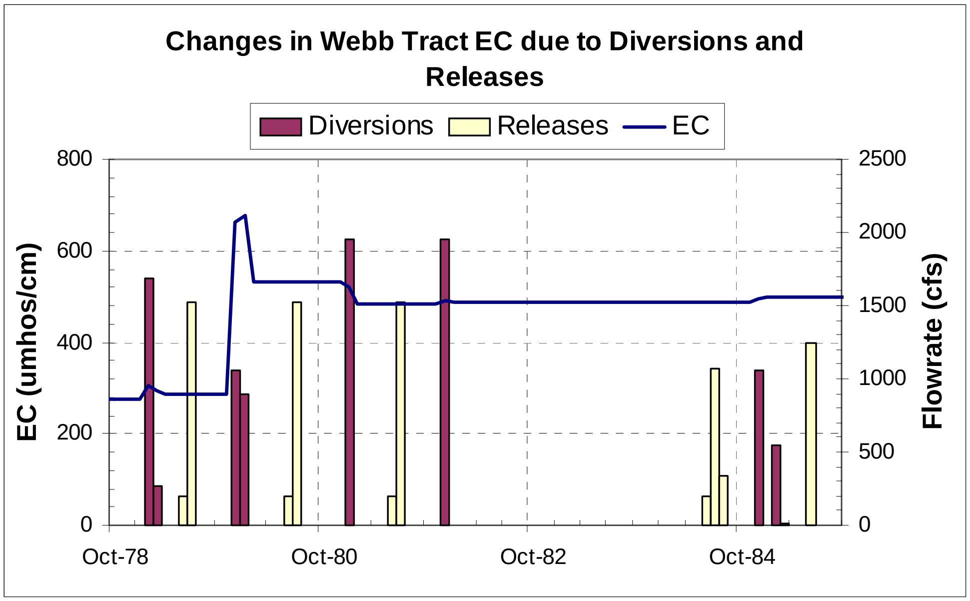

Figure 14: EC (umhos/cm) in Webb Tract.

The act of diverting water into and releasing it from the project islands only had minor changes on the Net Delta Outflow. As shown above in Figure 1, the combined amount of diversion to the islands never exceeded 4,000 cfs. Similarly, the releases (see Figure 2) never exceeded 2,000 cfs. The changes to Net Delta Outflow were fairly small, as is shown below in Figure 15.

Since the EC at downstream boundary (Martinez) was generated using an ANN with Net Delta Outflow as the input, a new EC boundary condition was calculated based on changes to the Net Delta Outflow. The modeled EC for both the base and alternative scenarios is shown below in Figure 16. These differences were fairly small.

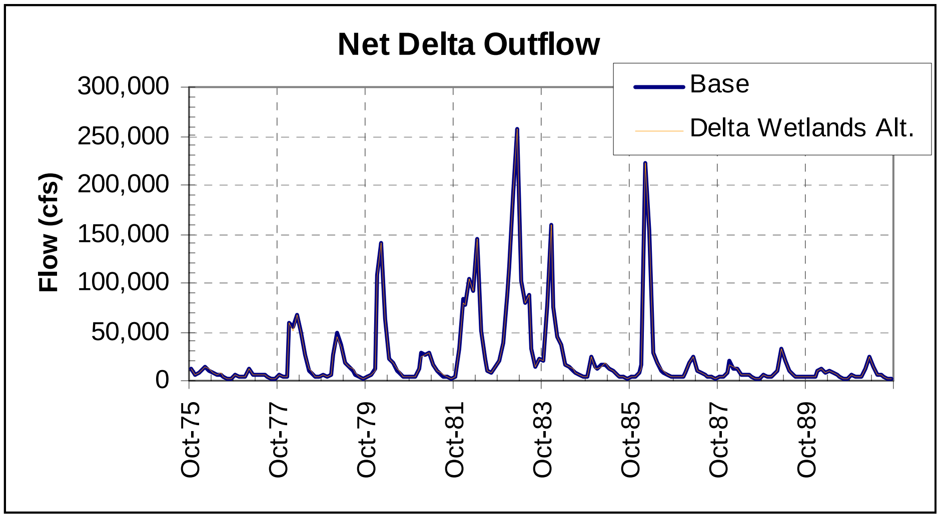

Figure 15: Net Delta Outflow.

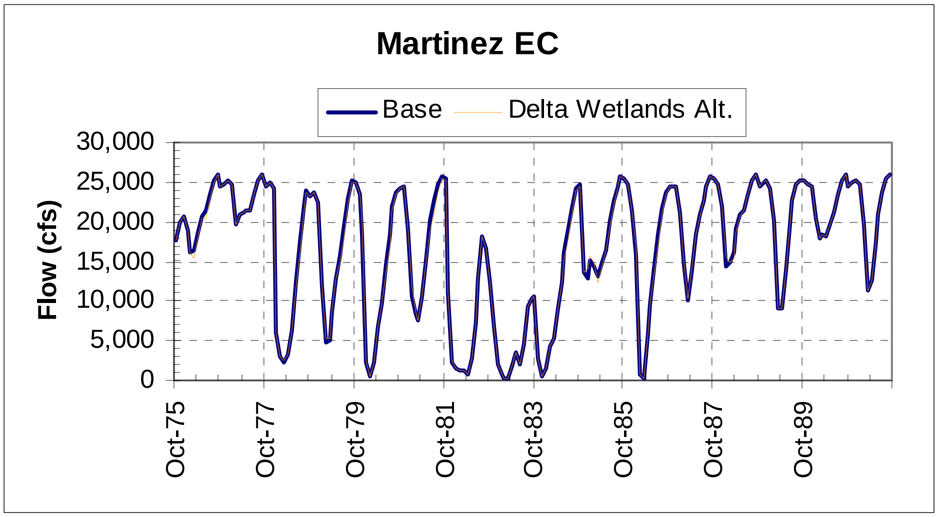

Figure 16: Martinez EC (umhos/cm).

Discharges from the islands did not change the water quality of the reservoirs (see Figures 13 and 14) and had little impact on the EC concentration in the Delta itself. The impacts of the releases from both project islands are compared to the base case scenario in Figures 17 - 28.

The EC values shown in Figures 17, 20, 23, and 26 are monthly averages that were computed using the daily EC values modeled by DSM2. It is important to remember that DWRSIM hydrology was based on a monthly time step, and that the downstream tidal boundary was represented by a repeating tide, which does not include the Spring / Neap cycle that would normally be associated with the draining and filling of the Delta. A chloride standard of 225 mg/l for Rock Slough is shown on all four figures. This standard was converted from Chloride to EC using the relationship shown in Equation 3. Traditionally, a 225 mg/l Cl standard at Rock Slough is used to account for the fact that the 250 mg/l daily standard is being modeled in monthly time steps by DWRSIM and DSM2. In this particular study, the WQMP calls for 90% of the same daily standard (which just happens to be 225 mg/l).

$$EC_{Rock\,Slough} = \frac{Chloride_{Rock\,Slough} + 24}{0.268} \qquad \text{[Eqn. 3]}$$

The Rock Slough Chloride standard was exceeded at all four urban intake locations for both the base and alternative studies. In fact there is little difference in EC between the two studies. However, since this standard was exceeded for even the base case[3], it makes it difficult to evaluate the impact of the Delta Wetlands project operations on the four urban intake locations.

[3] DSM2 base case violations of the Rock Slough chloride standard are caused by the mismatch between the G-Model used by DWRSIM and DSM2. An ANN trained using DSM2 has been incorporated into CALSIM II. When future Delta Wetlands DSM2 studies are based on CALSIM operations, this mismatch should be resolved.

The cumulative distribution function (cdf) of EC for each of the four urban intake locations is shown in Figures 18, 21, 24, and 27. Each cdf curve represents the amount of time that EC is equal to or less than a corresponding EC concentration. For example, the 225 mg/l standard shown in Figure 18 is met approximately 74% of the time for both simulations. These cdfs were calculated based on the frequency histograms for absolute EC for every month of the entire 16-year simulations. Again, there is no significant difference between the base and alternative studies at all four locations.

The WQMP also limits the increase in salinity at any of the urban intakes due to project operation to 10 mg/l chloride (which is equivalent to 37 umhos/cm). The cdf for the change (measured as alternative – base case EC) in EC at each location is shown in Figures 19, 22, 25, and 28. These figures illustrate that over the study period that the overall changes in EC tended to be between –50 and 50 umhos/cm. These plots are useful in measuring the impact of the Delta Wetlands project operations on the four urban intake locations.

A summary of the increase in salinity at the urban intakes is shown below in Table 5. The project islands resulted in increases above the WQMP 10 mg/l chloride standard between 5-6% of the time at both the Old River at Rock Slough and Old River at the Los Vaqueros Reservoir intakes.

Table 5: Percent of time that the change in Cl is larger than 10 mg/l.

Location	***% Exceedence***
Old River at Rock Slough	6
Old River at Los Vaqueros intake	5
State Water Project	3
Central Valley Project	3

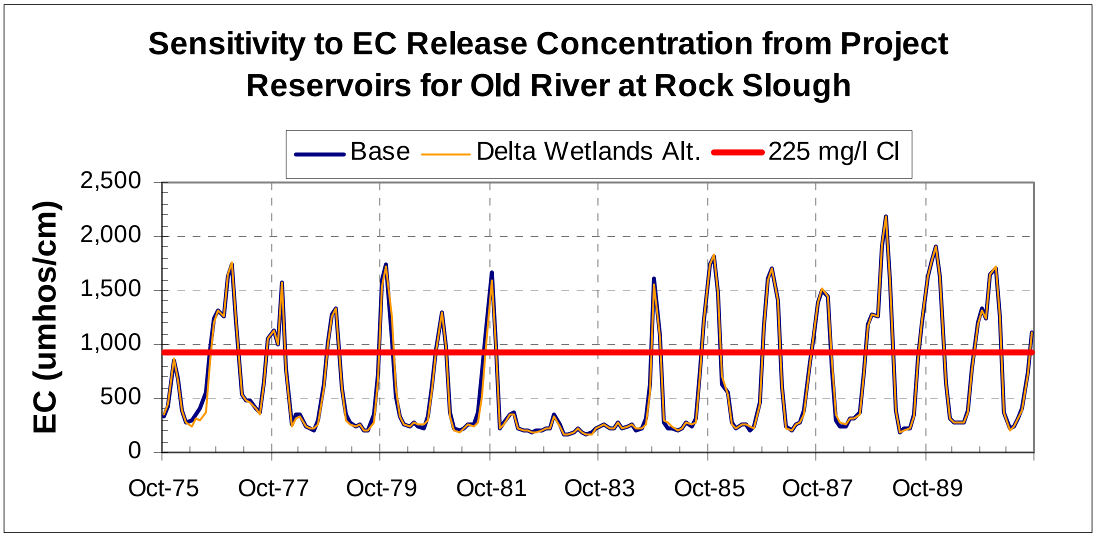

Figure 17: Sensitivity to EC Release Concentration from Project Reservoirs for Old River at Rock Slough.

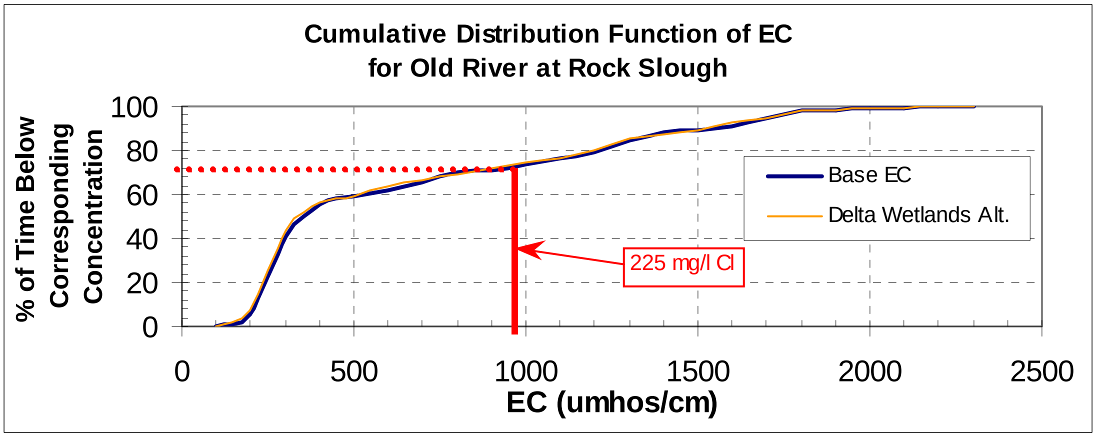

Figure 18: Cumulative Distribution Function of EC for Old River at Rock Slough.

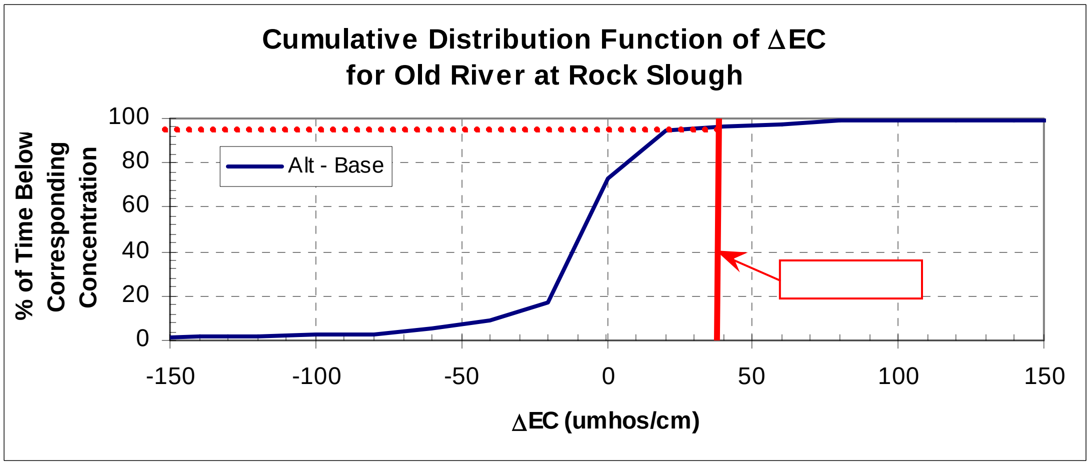

Figure 19: Cumulative Distribution Function of ΔEC for Old River at Rock Slough.

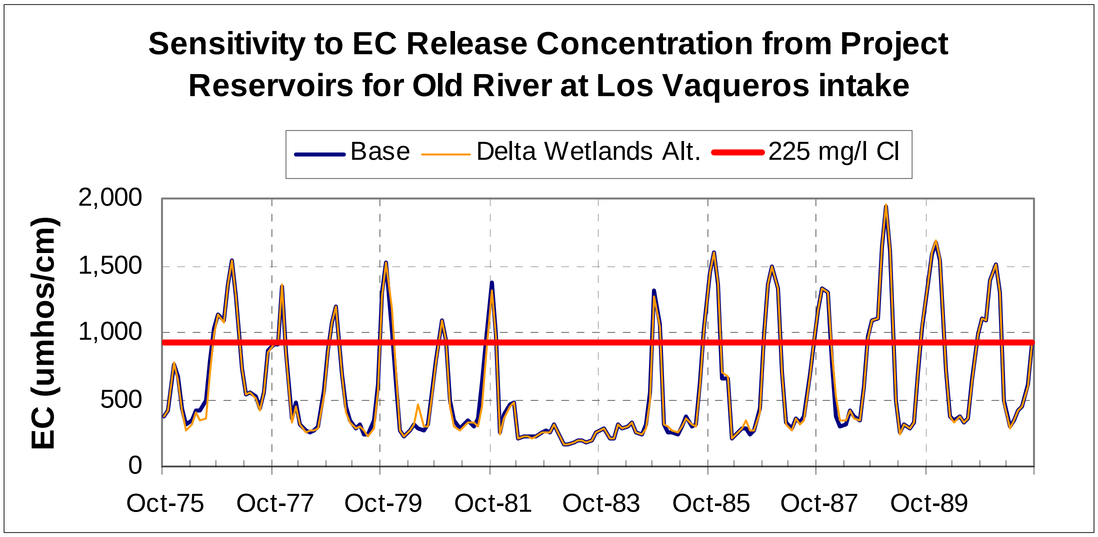

Figure 20: Sensitivity to EC Release Concentration from Project Reservoirs for Old River at Los Vaqueros.

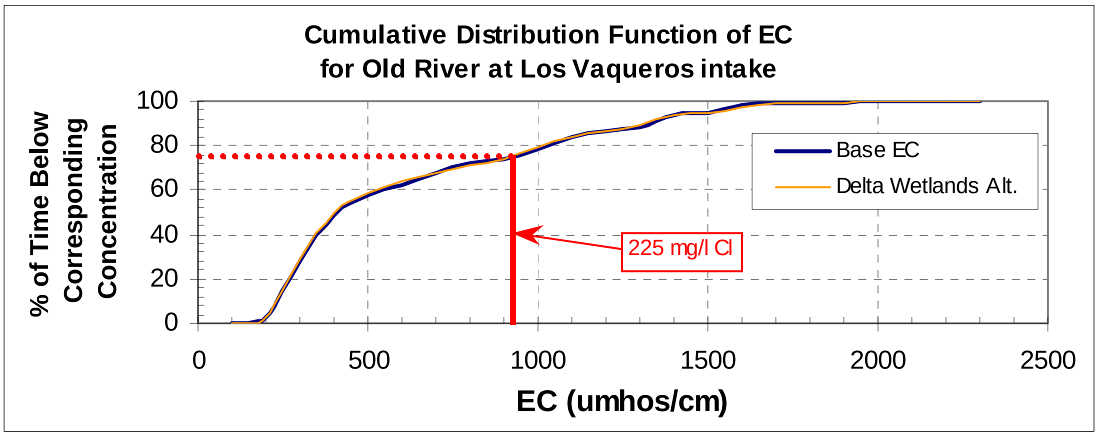

Figure 21: Cumulative Distribution Function of EC for Old River at Los Vaqueros.

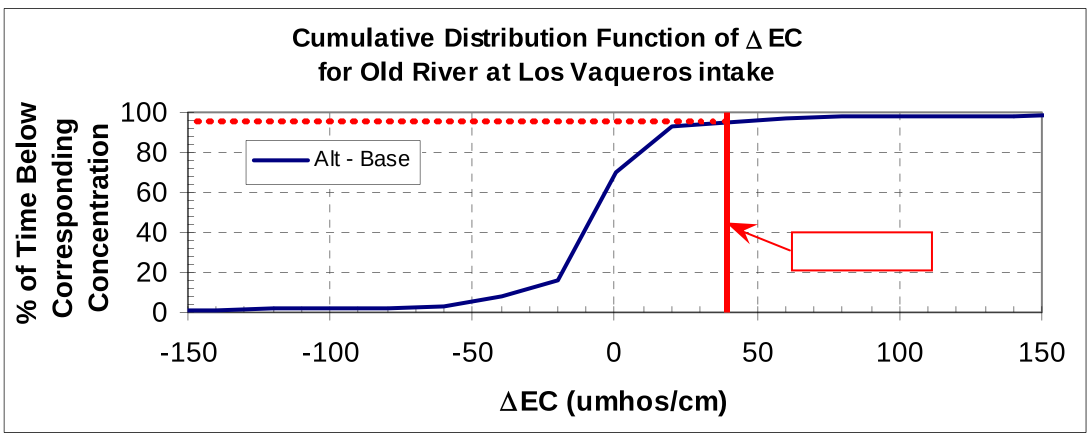

Figure 22: Cumulative Distribution Function of ∆EC for Old River at Los Vaqueros.

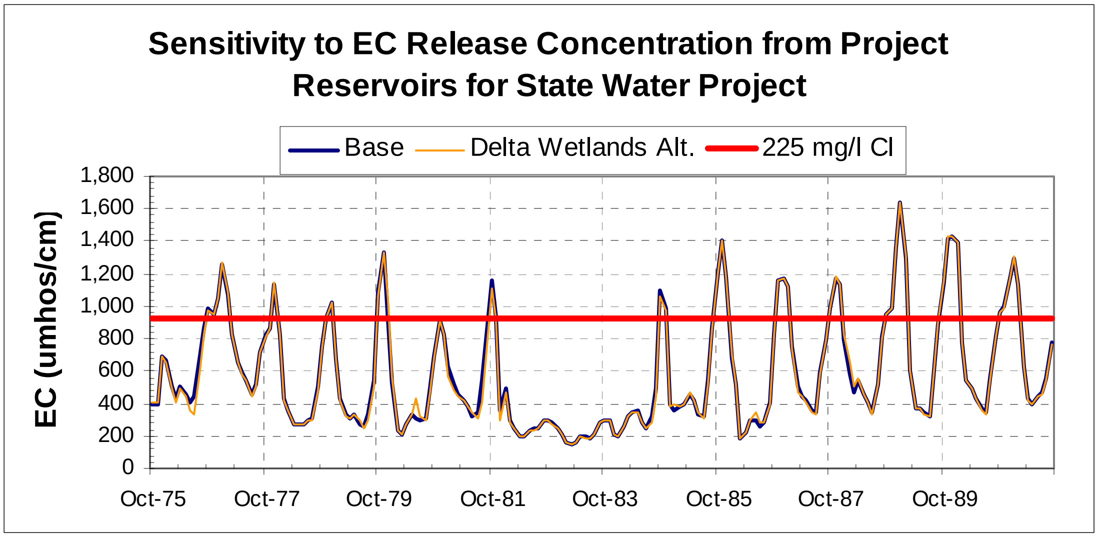

Figure 23: Sensitivity to EC Release Concentration from Project Reservoirs for State Water Project.

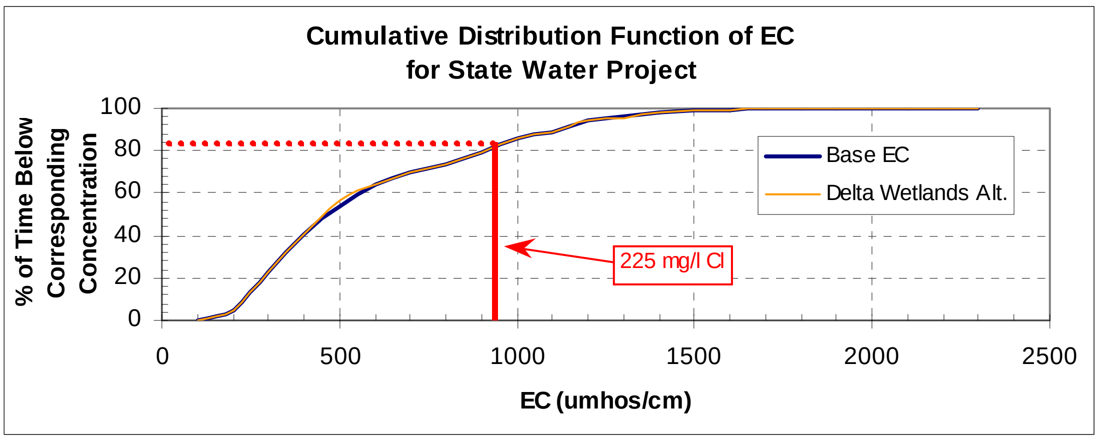

Figure 24: Cumulative Distribution Function of EC for State Water Project.

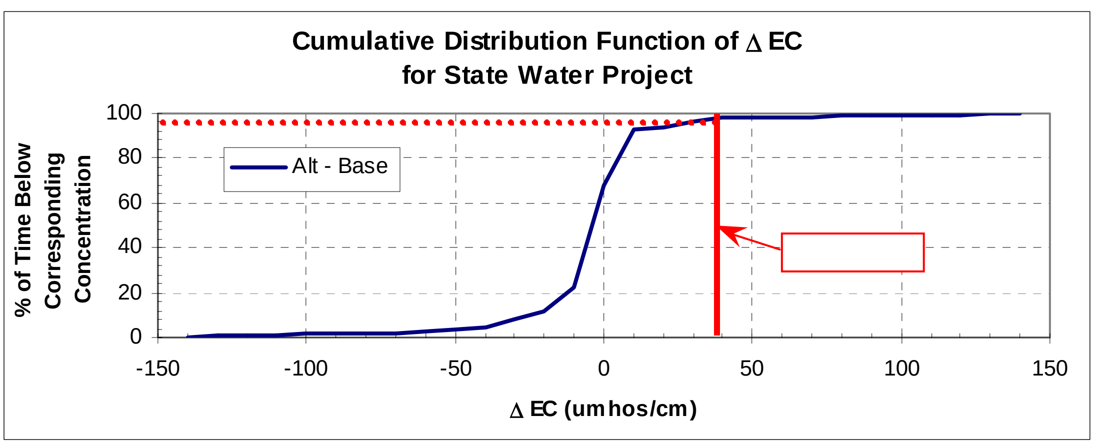

Figure 25: Cumulative Distribution Function of ΔEC for State Water Project.

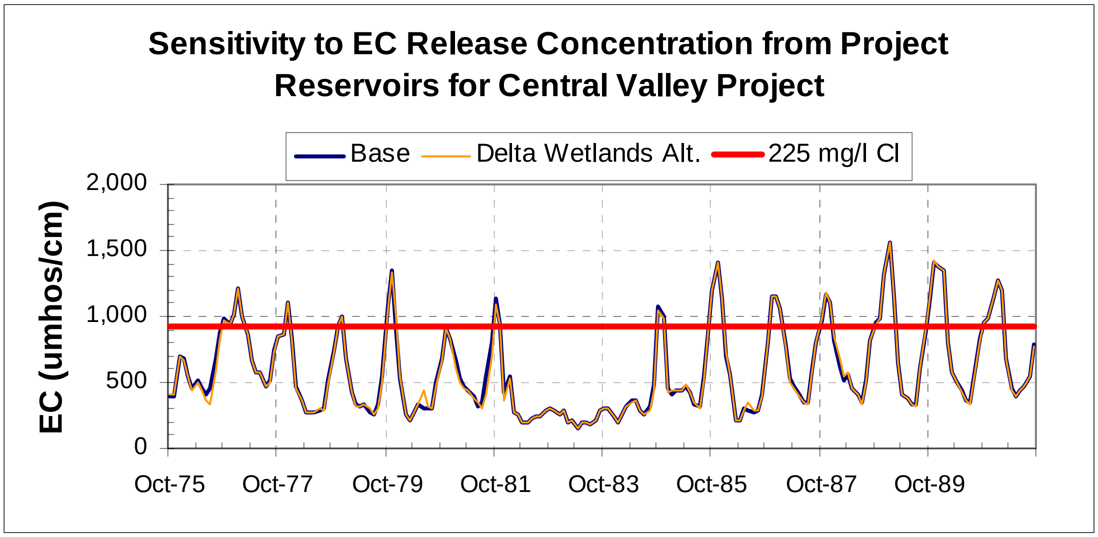

Figure 26: Sensitivity to EC Release Concentration from Project Reservoirs for Central Valley Project.

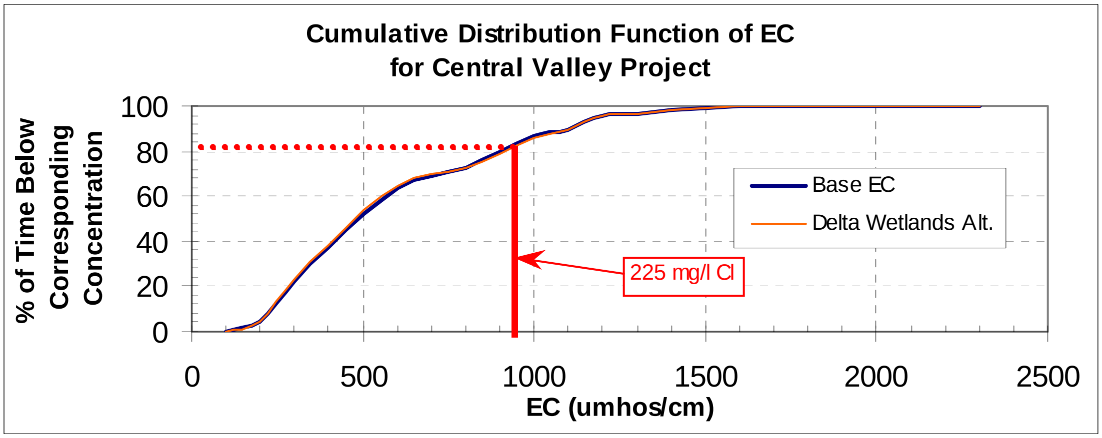

Figure 27: Cumulative Distribution Function of EC for Central Valley Project.

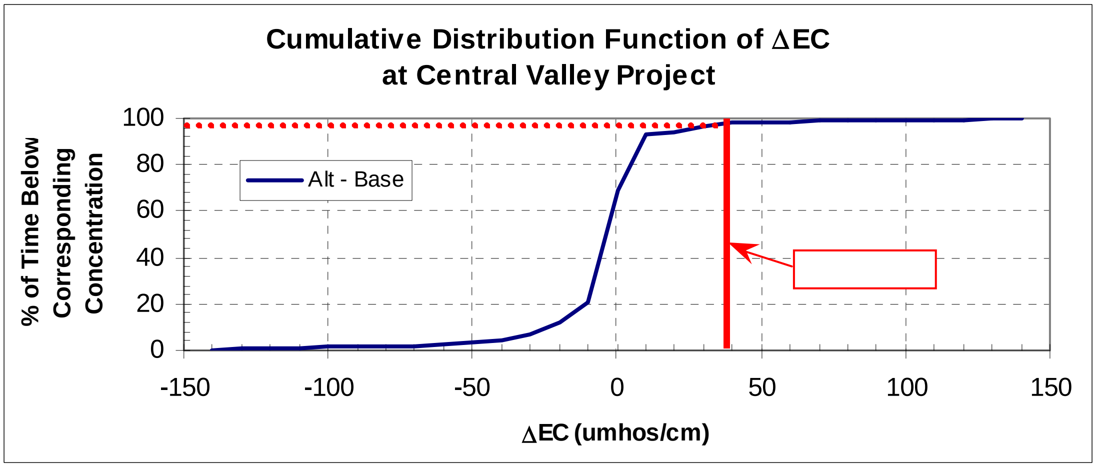

Figure 28: Cumulative Distribution Function of ΔEC for Central Valley Project.

4.2. DOC

Three different bookend DOC simulations were run to create bookends for the impacts on DOC due to the operation of the Delta Wetlands project. The level of the DOC releases for each of these simulations is described above in Table 4 (see Section 2.2).

It was not necessary to model the two islands as reservoirs (as was done for EC modeling). The diversions into the reservoirs were treated as standard diversions. Water was removed from the Delta at the planned intake locations. Similarly, the releases from the islands were treated as rim or return flows at the planned discharge locations. Fixed DOC concentrations were assigned to these releases. The DOC from these releases would then mix with the DOC present in the Delta that came from both the rim boundaries and DICU data (as described above in the simulation inputs section).

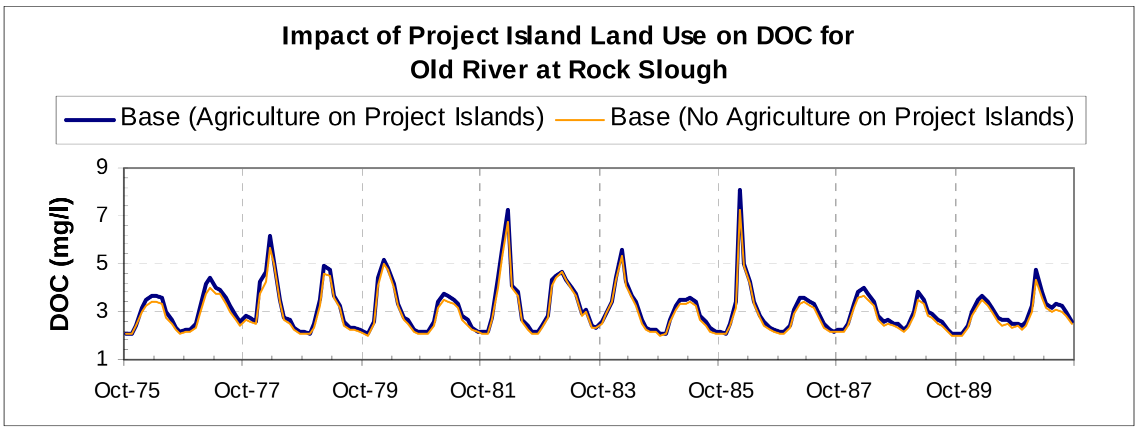

Figure 29: Effect of DICU around the Delta Wetlands Islands on Old River at Rock Slough.

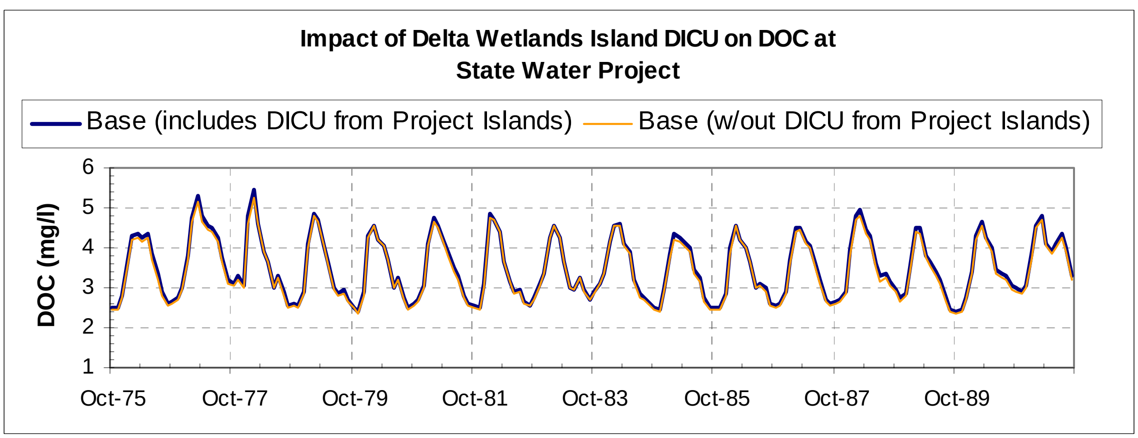

Figure 30: Effect of DICU around the Delta Wetlands Islands at the SWP.

In order to assess the effect of changing the land use on the project islands independently of the planned Delta Wetlands Project operations, an additional scenario, where only the consumptive use for Bacon Island and Webb Tract was changed, was run. This difference is referred to as the *DOC ag credit*. As shown in Figures 29 and 30, the *DOC ag credit* at both Old River at Rock Slough and at the State Water Project Tracy Pumping plant is relatively small.

Figures 31, 34, 37, and 40 illustrate the sensitivity to DOC release concentrations at each of the four urban intake locations: Old River at Rock Slough, Old River at the Los Vaqueros intake, the State Water Project intake at Banks Pumping Plant, and the Central Valley Project intake at Tracy. The 4 mg/l DOC standard described in the Delta Wetlands Water Quality Management Plan (WQMP) is shown on these figures.

The base case DOC concentration at Rock Slough, as shown in Figures 29 and 31, ranged between 2 and 8 mg/l. Further south at the State Water Project (see Figures 30 and 37), DOC ranged from 2.5 mg/l to 5.5 mg/l. The maximum monthly averaged DOC concentration at all four export locations over the entire 16-year planning study is summarized in Table 6.

Table 6: Maximum monthly averaged DOC (mg/l) concentrations.

Location	***Base***	***Low (6 mg/l)***	***Mid (15 mg/l)***	***High (30 mg/l)***
Old River at Rock Slough	8.10	7.03	7.03	7.03
Old River at Los Vaqueros intake	7.90	7.57	10.59	19.37
State Water Project	5.43	5.11	7.89	12.57
Central Valley Project	5.13	5.01	7.47	11.58

In the base case, the periods of high DOC for all of the locations coincided with the high runoff periods that start in the spring and sometimes last through early summer. The *DOC ag credit* discussed above typically appeared to lower the DOC concentrations in the early spring period for all three bookend scenarios at Rock Slough (see Figure 31), but was less significant at the other three urban intake locations (see Figures 34, 37, and 40). The increases in the maximum monthly averaged DOC concentration at all four intake locations in the alternative scenarios occurred in the summer months and correspond with the project island release periods.

The Los Vaqueros intake on the Old River had the highest modeled DOC concentrations for all three alternative scenarios. The Los Vaqueros intake is located between the Bacon Island discharge point and the SWP and CVP intakes, so it is not surprising that the DOC concentrations for Los Vaqueros are higher than the other three locations.

The maximum monthly increase in DOC for each of the bookend scenarios is shown in Table 7. The largest increases for all three simulations were at the Los Vaqueros intake.

Table 7: Maximum monthly increase in DOC (mg/l).

Location	***Low – Base***	***Mid - Base***	***High - Base***
Old River at Rock Slough	0.34	1.63	3.77
Old River at Los Vaqueros intake	0.95	5.97	14.75
State Water Project	0.66	3.09	12.57
Central Valley Project	0.66	3.00	6.91

The impact of the project operations is better illustrated in Figures 32, 36, 39, and 42 as a time series of the change in DOC (alternative – base). The WQMP limits the maximum increase in DOC due to project operations based on the modeled base case DOC concentration. When the base case DOC is either less than 3 mg/l or greater than 4 mg/l, the maximum increase in DOC is 1 mg/l. When the base case DOC is between 3 mg/l and 4 mg/l, then the alternative DOC can not exceed 4 mg/l. This standard is illustrated as a changing time series with values between 0 to 1 mg/l.

At Old River at Rock Slough the low – base difference did not exceed the WQMP maximum increase in DOC standard. With the exception of the summers of 1984 and 1987 the mid – base difference exceeded the WQMP maximum increase standard. Furthermore, it should be noted that the Webb Tract release in the summer of 1987 was only 432 cfs and there was no Bacon Island release during this period (see Figure 2), which explains why even the high – base difference did not exceed the maximum increase standard in 1987.[4] There was a similar trend in results at the other three urban intake locations. However, the low – base difference did exceed the WQMP at each of the other three urban intake locations in the summer of 1981 (see Figures 35, 38, and 41).

Frequency histograms of the change in DOC for the entire simulation period were used to create cumulative distribution functions (cdfs) representing the relative change in DOC for each location. These cdfs are shown in Figures 34, 37, 40, and 43. On each cdf, a 1 mg/l limit is shown. The point where this limit intersects each of the three cdf curves represents the percentage of time that the change in DOC due to project operations will be equal to or less than the limit

For example, according to Figure 34, high DOC releases from the project islands will result in changes in DOC at Rock Slough that are equal to or less than 1 mg/l 90% of the time. Similarly, this means that 10% of the time the operation of the project will result in increases in DOC at Rock Slough that are greater than 1 mg/l. A summary of the increases in DOC due to the operation of the project for the entire simulation period is shown below in Table 8.

Table 8: Percent of time that the change in DOC is larger than 1 mg/l.

Location	***% Exceedence Low – Base***	***% Exceedence Mid – Base***	***% Exceedence High – Base***
Old River at Rock Slough	0	4.7	9.9
Old River at Los Vaqueros intake	0	7.3	14.6
State Water Project	0	4.7	10.9
Central Valley Project	0	4.7	10.9

[4] The Delta Wetlands preliminary operational diversion and release schedule did not completely fill Bacon Island in the spring of 1987. Using the operational rules discussed in Section 2.2, the summer releases of 1987 were met using the over-year storage of Webb Tract. The summer 1987 release was only 432 cfs, which is less than half of any of the other releases from Webb Tract. According to the Delta Wetlands operational release schedule Webb Tract releases typically ranged from 1000 to 1500 cfs.

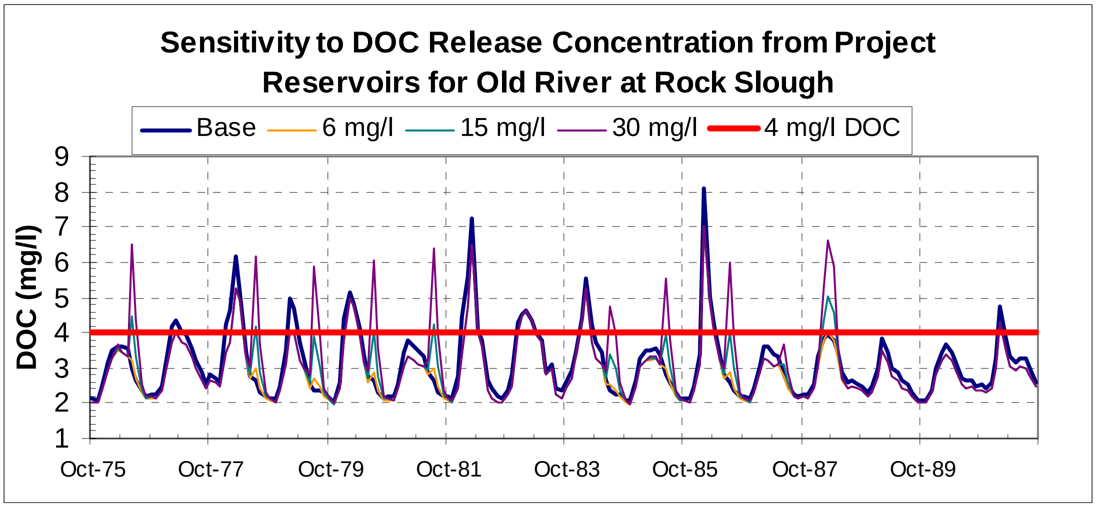

Figure 31: Time Series of DOC for Old River at Rock Slough.

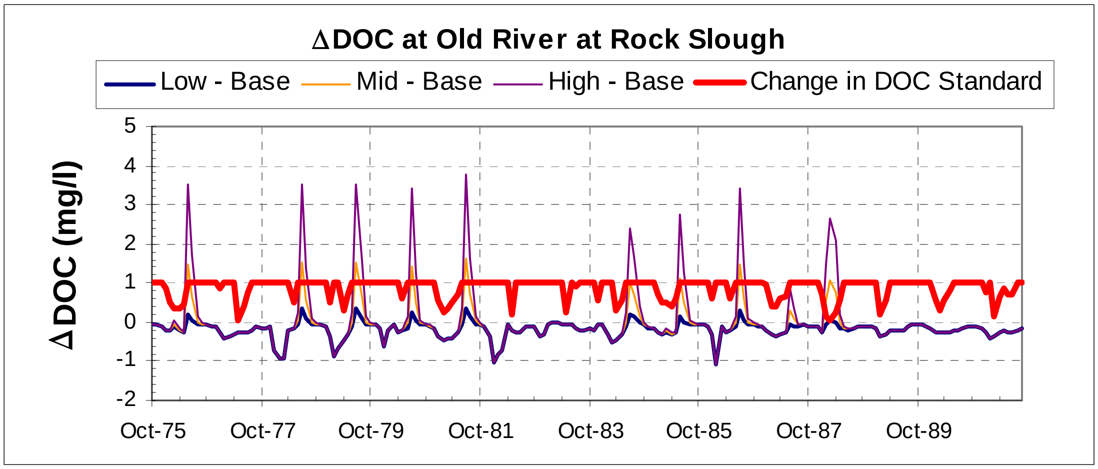

Figure 32: Time Series of Change in DOC (Alternative – Base) for Old River at Rock Slough.

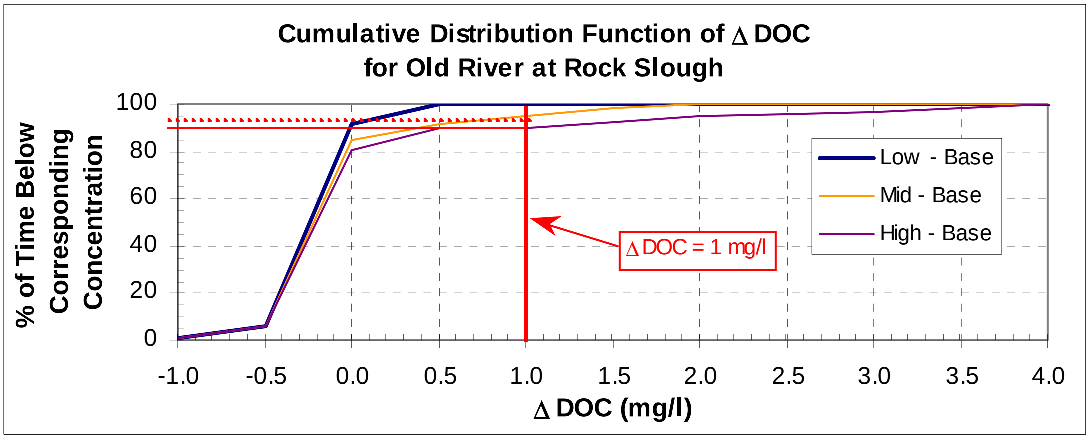

Figure 33: Cumulative Distribution Function of Change in DOC (Alternative – Base) for Old River at Rock Slough.

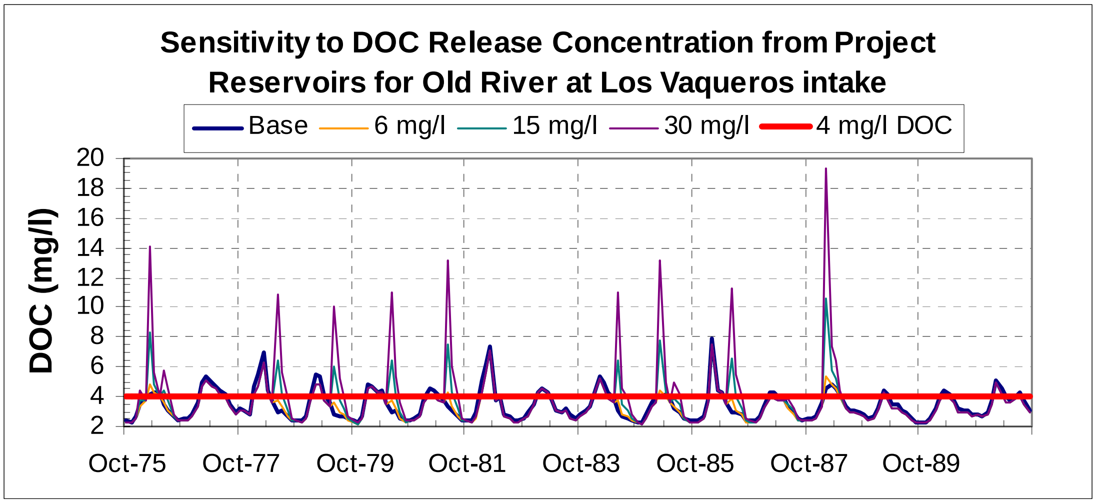

Figure 34: Time Series of DOC for Old River at Los Vaqueros intake.

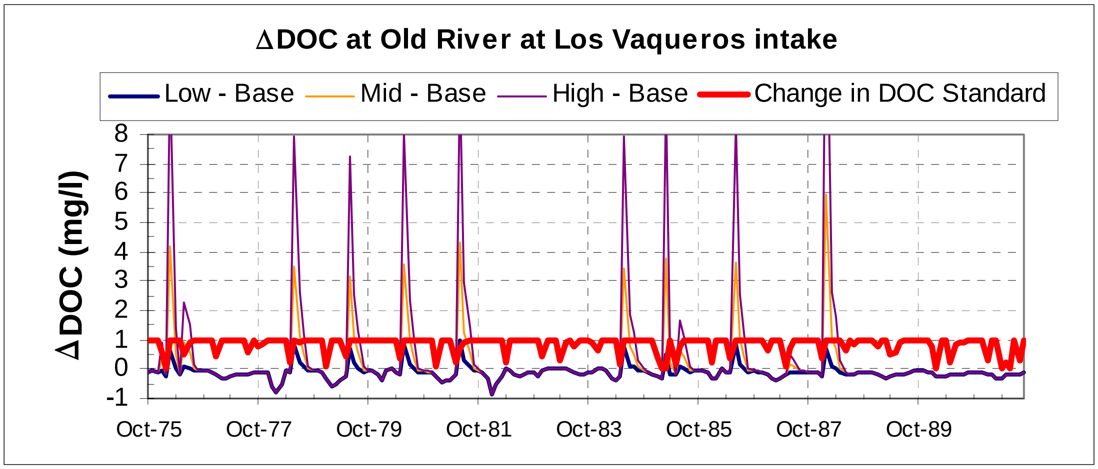

Figure 35: Time Series of Change in DOC (Alternative – Base) for Old River at Los Vaqueros intake.

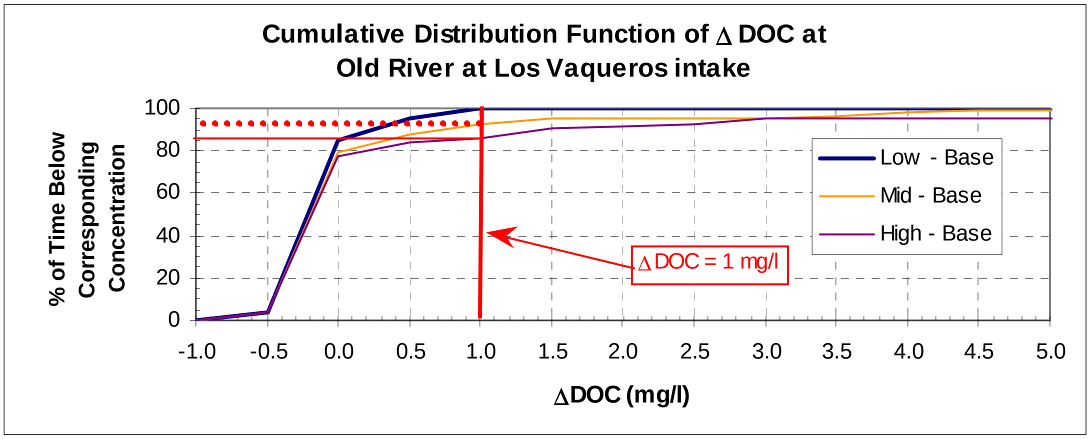

Figure 36: Cumulative Distribution Function of Change in DOC (Alternative – Base) for Old River at Los Vaqueros intake.

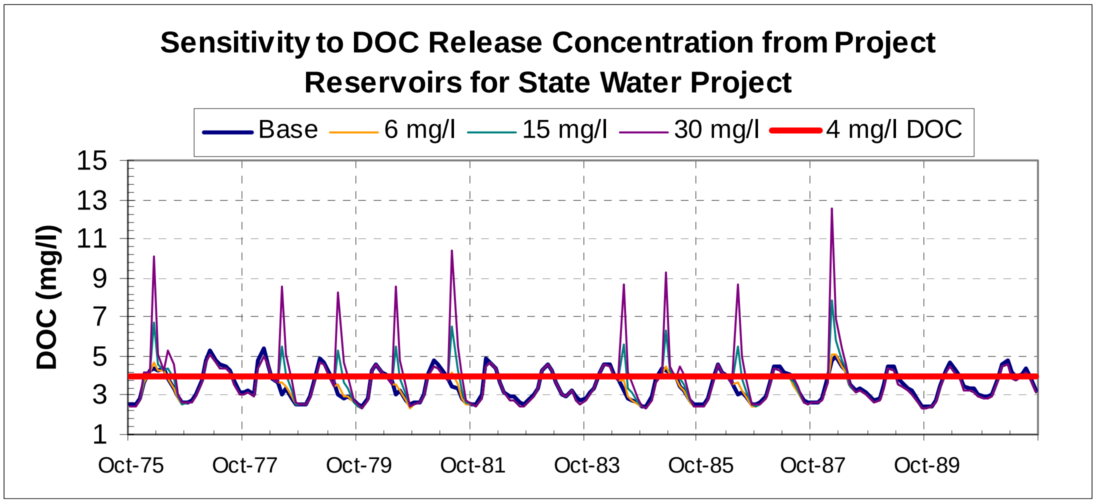

Figure 37: Time Series of DOC for the State Water Project.

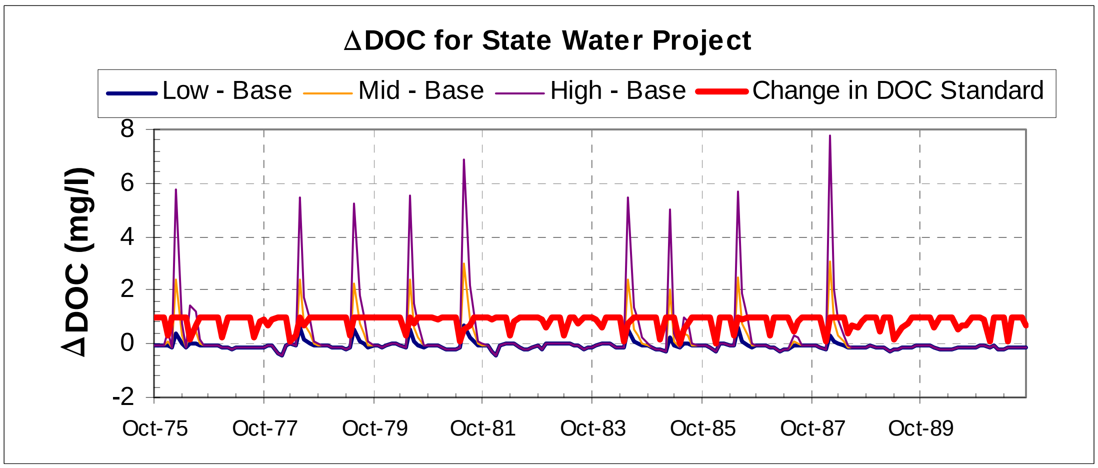

Figure 38: Time Series of Change in DOC (Alternative – Base) for the State Water Project.

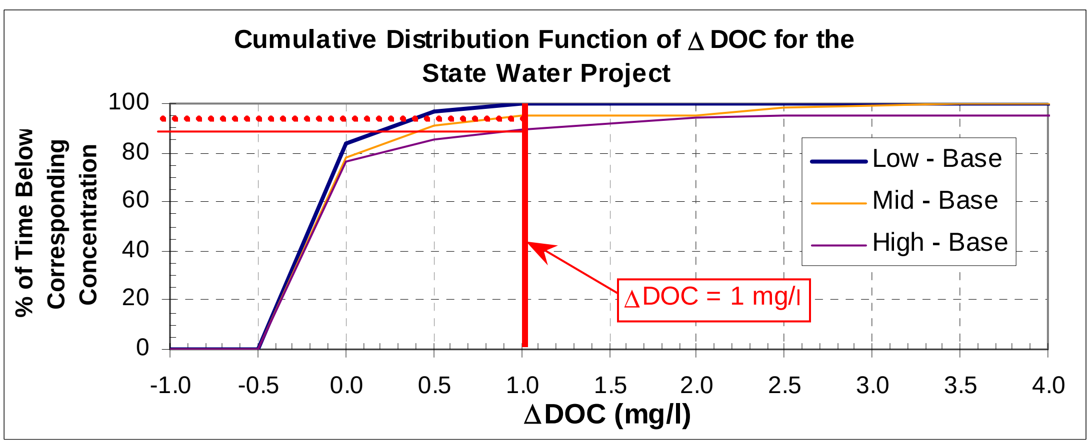

Figure 39: Cumulative Distribution Function of Change in DOC (Alternative – Base) for the State Water Project.

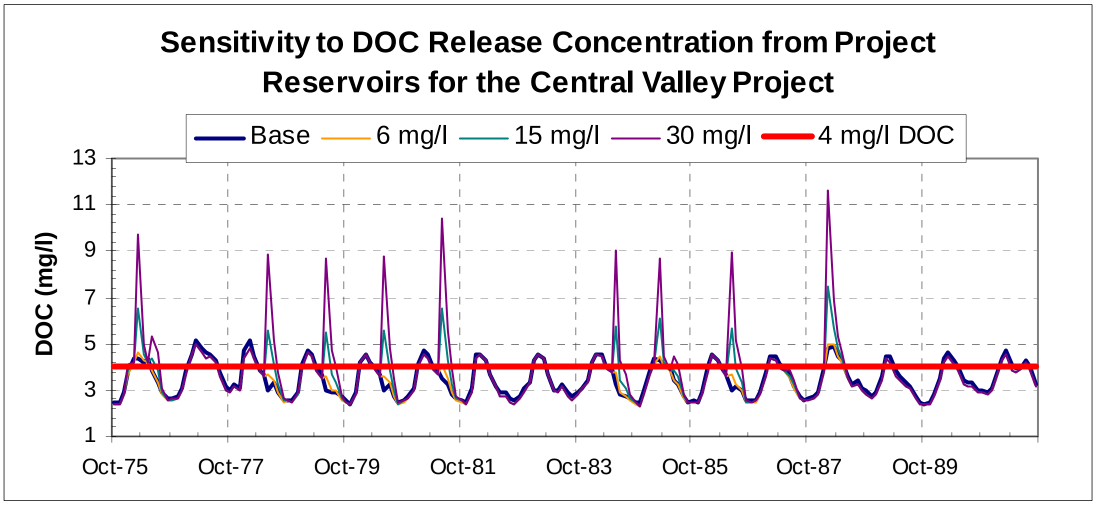

Figure 40: Time Series of DOC for the Central Valley Project.

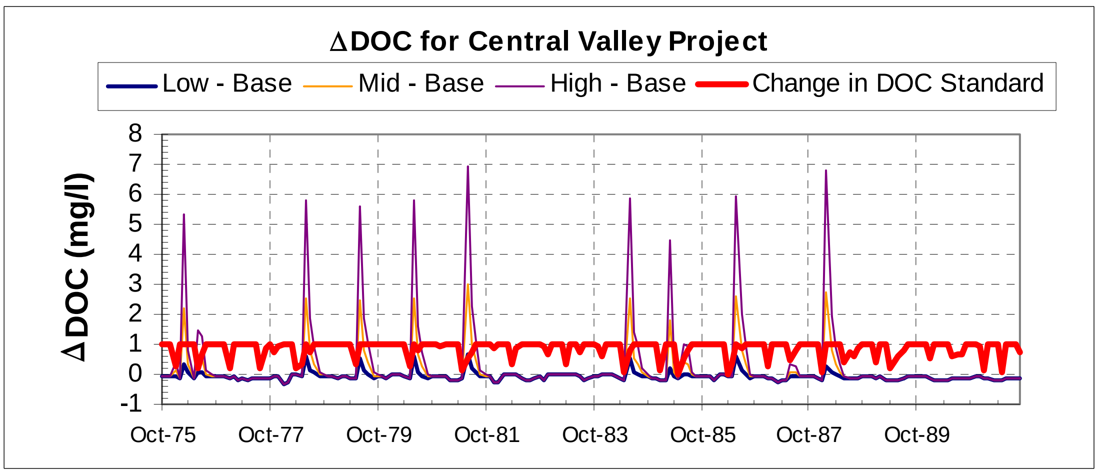

Figure 41: Time Series of Change in DOC (Alternative – Base) for the Central Valley Project.

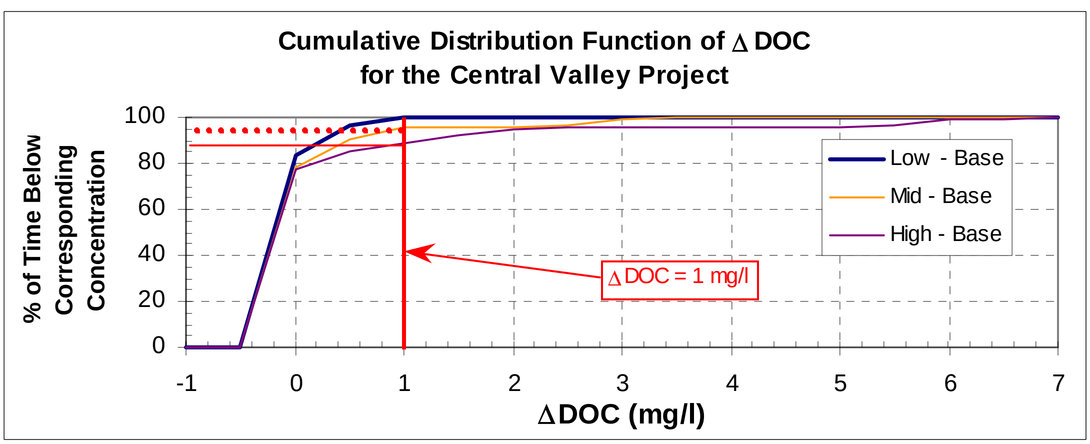

Figure 42: Cumulative Distribution Function of Change in DOC (Alternative – Base) for the Central Valley Project.

4.3. Long-Term DOC

The mass loading of DOC for the State Water Project and Central Valley Project was calculated by multiplying the DSM2 modeled DOC concentrations with the DWRSIM 771 monthly exports for each location. The mass loading of DOC for the Old River at Rock Slough and Old River at the Los Vaqueros Intake was calculated by multiplying the DSM2 modeled DOC concentrations with planned future CCWD diversions developed using CCWD's CCWDOPs model (Denton 2001)[5].

The WQMP stipulated that the long-term increase in DOC mass loading be calculated as a 3-year running average. Time series plots of the long-term DOC mass loading (expressed in 1000 metric tons / month) at each of the urban intake locations are shown in Figures 43, 46, 49, and 52. The low-DOC release concentration (6 mg/l) from the project islands resulted in long-term DOC mass loading that closely resembled the base case long-term DOC mass loading at all four urban intake locations. Similarly, the high-DOC release concentration (30 mg/l) from the project islands was uniformly higher than the base case DOC mass loading.

The 3-year running averages for both the base case and alternative scenarios were then used to calculate the increases in long-term DOC mass loading using Equation 4.

$$\%DOC_{Increase\,w/\,Project} = \frac{DOC_{w/\,Project} - DOC_{w/\,o\,project}}{DOC_{w/\,o\,project}} \times 100\% \qquad \text{[Eqn. 4]}$$

The WQMP limits the long-term DOC mass loading increases at the intake locations due to the project operation to 5%. This 5% limit is shown on the time series plots (Figures 44, 47, 50, and 53) of the long-term percent increase of DOC mass loading at each of the intake locations. As discussed above, the low-DOC release concentration from the project islands did not result in a long-term increase in DOC mass loading at any of the intakes. The maximum percent increases in the long-term DOC mass loading are shown in Table 9.

Table 9: Maximum Percent Increase in Long-Term DOC Mass Loading.

Location	*Low – Base*	*Mid – Base*	*High – Base*
Old River at Rock Slough	-2	12	33
Old River at Los Vaqueros intake	0	14	38
State Water Project	-1	6	18
Central Valley Project	0	9	23

Frequency histograms of the percent increase in long-term DOC mass loading for the entire simulation period were used to create cumulative distribution functions (cdfs) to represent the long-term impact of the project operations. These cdfs are shown in Figures

[5] The DSM2 simulation did not separate the CCWD diversions from Old River at Rock Slough and Old River at the Los Vaqueros Intake location. Instead DWRSIM 771 diversions at Rock Slough were used to represent CCWD's total diversions. Future DSM2 simulations will make use of the CCWD CCWDOPs planned diversion data.

45, 48, 51, and 54. The WQMP maximum 5% increase in long-term DOC mass loading standard is shown on each figure. The low-DOC release scenario did not exceed this WQMP standard for any of the intake locations. However, both the mid- and high-DOC release scenarios exceeded the 5% limit at each location.

The percent of the time that each scenario was equal to or below the WQMP maximum 5% increase standard is shown in Table 10. The largest increases in long-term DOC mass loading occurred at Los Vaqueros Reservoir intake on the Old River.

Table 10: Percent Time that the Percent Increase of Long-Term DOC Mass Loading meets the WQMP maximum 5% increase standard.

Location	***Low – Base***	***Mid – Base***	***High – Base***
Old River at Rock Slough	100	48	29
Old River at Los Vaqueros intake	100	39	4
State Water Project	100	84	30
Central Valley Project	100	66	21

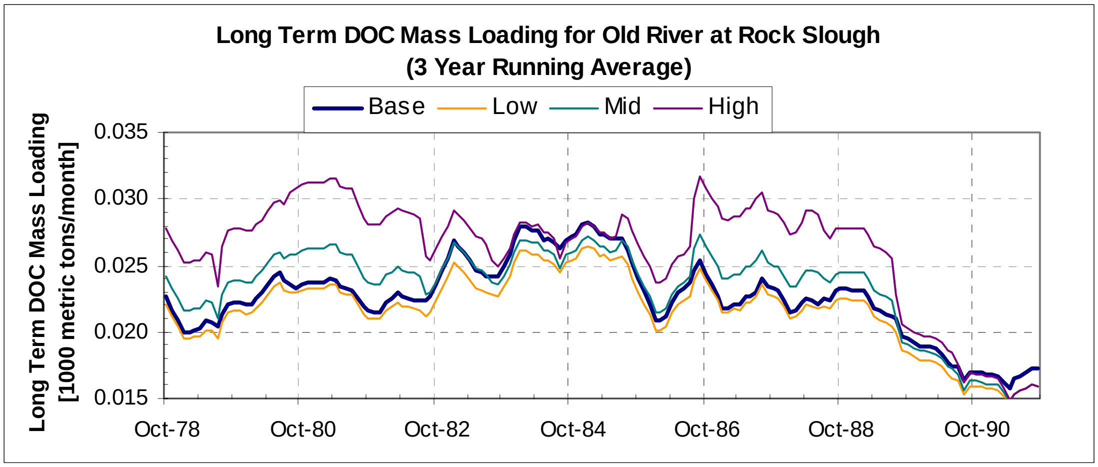

Figure 43: Long Term DOC Mass Loading for Old River at Rock Slough based on a 3-Year Running Average.

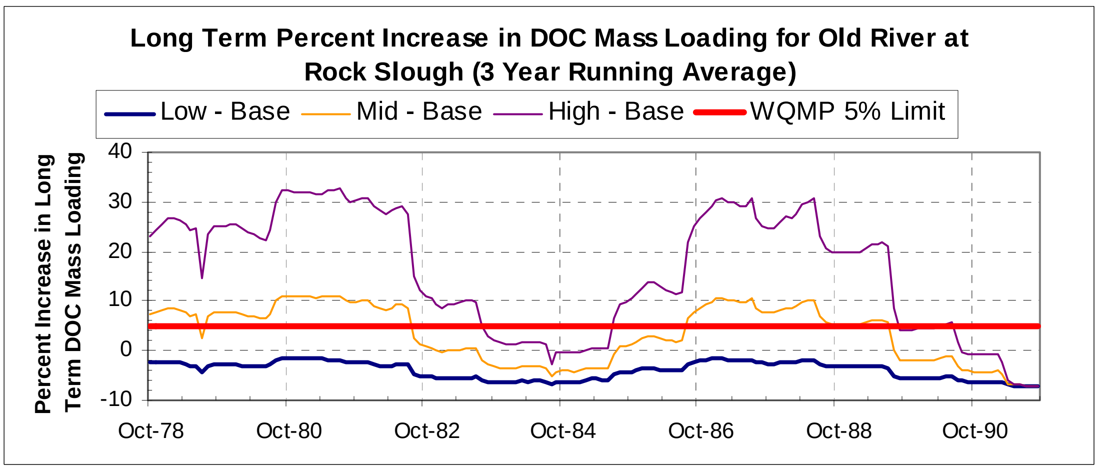

Figure 44: Percent Increase in Long Term DOC Mass Loading for Old River at Rock Slough based on a 3-Year Running Average.

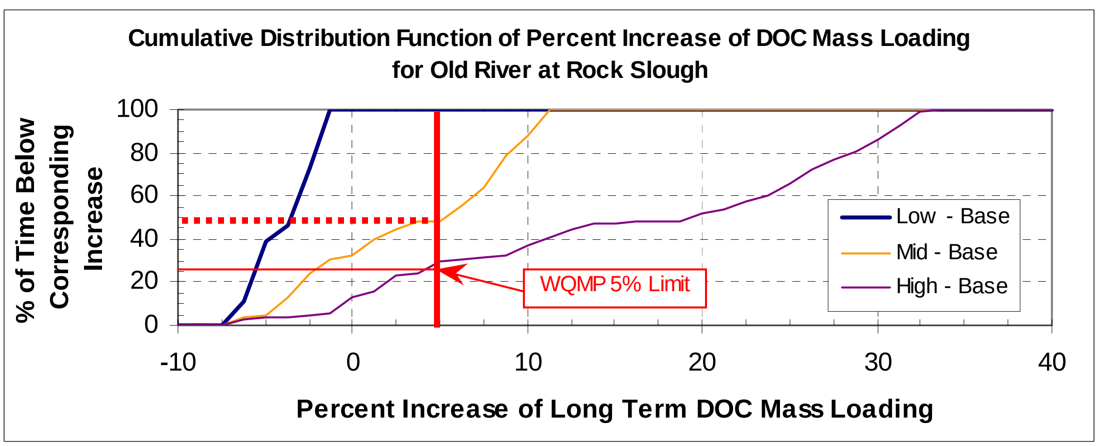

Figure 45: Cumulative Distribution Function of Percent Increase of Long Term DOC Mass Loading for Old River at Rock Slough.

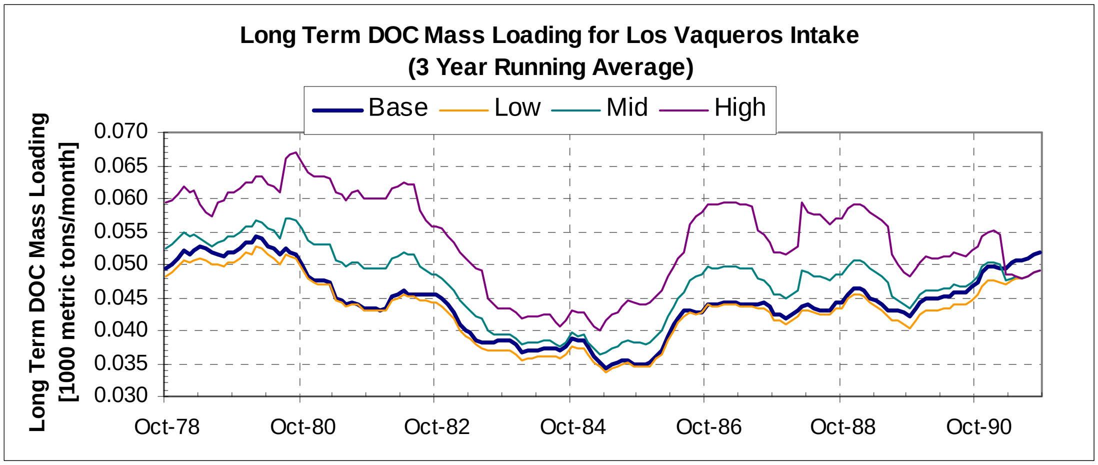

Figure 46: Long Term DOC Mass Loading for Old River at Los Vaqueros intake based on a 3-Year Running Average.

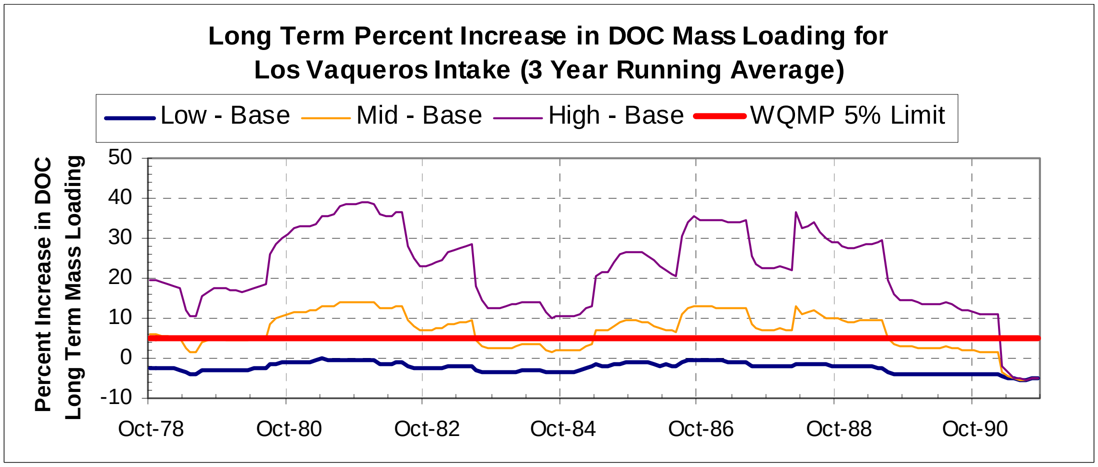

Figure 47: Percent Increase in Long Term DOC Mass Loading for Old River at Los Vaqueros intake based on a 3-Year Running Average.

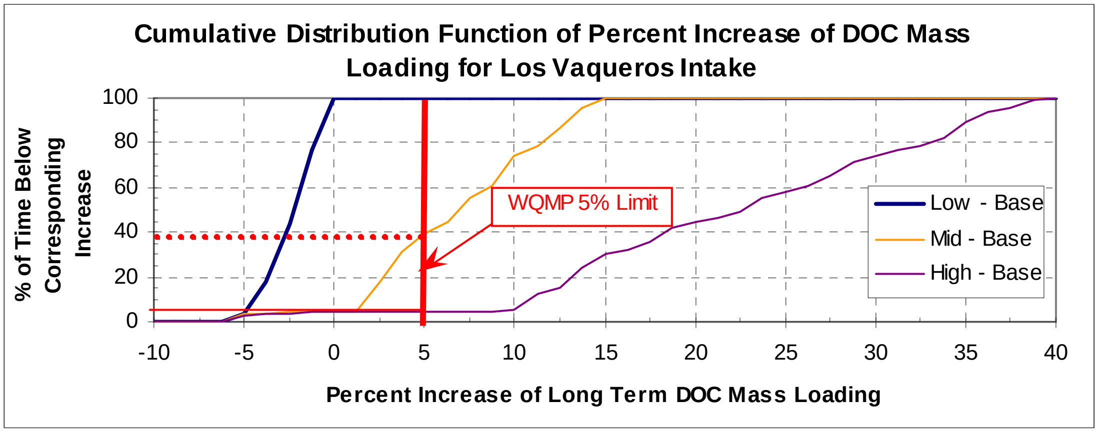

Figure 48: Cumulative Distribution Function of Percent Increase of Long Term DOC Mass Loading for Old River at Los Vaqueros intake.

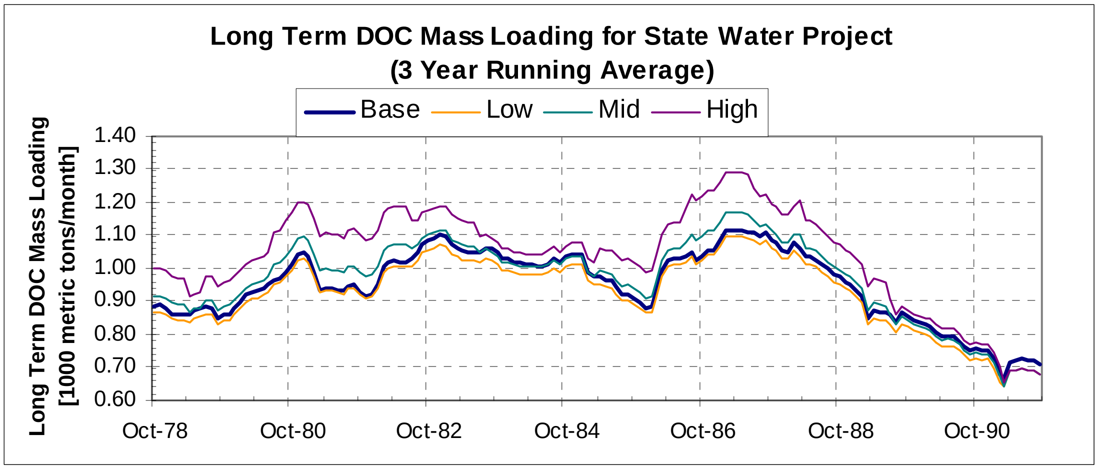

Figure 49: Long Term DOC Mass Loading for State Water Project based on a 3-Year Running Average.

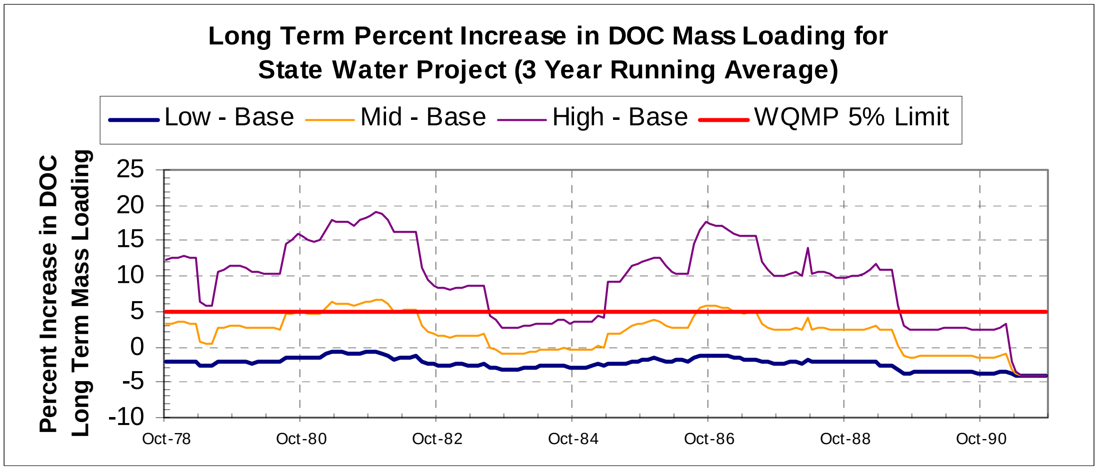

Figure 50: Percent Increase in Long Term DOC Mass Loading for State Water Project based on a 3-Year Running Average.

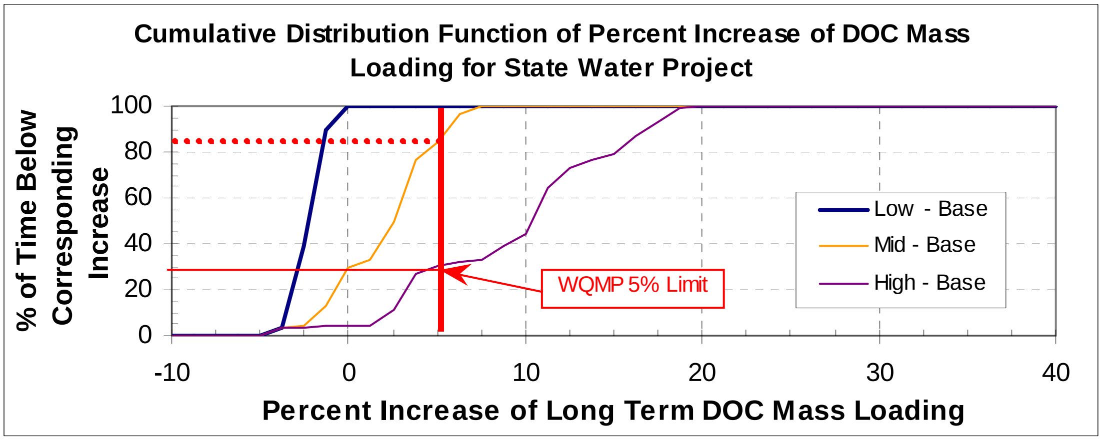

Figure 51: Cumulative Distribution Function of Percent Increase of Long Term DOC Mass Loading for State Water Project.

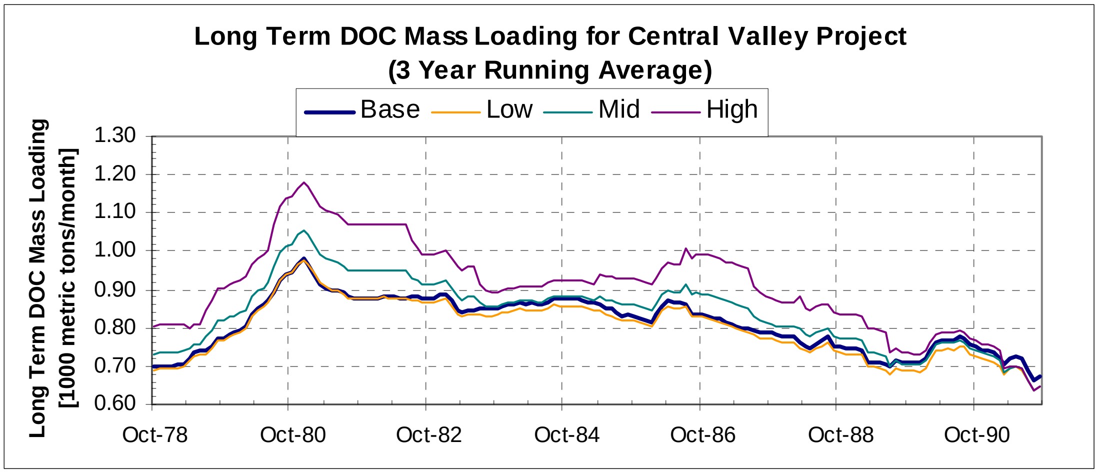

Figure 52: Long Term DOC Mass Loading for Central Valley Project based on a 3-Year Running Average.

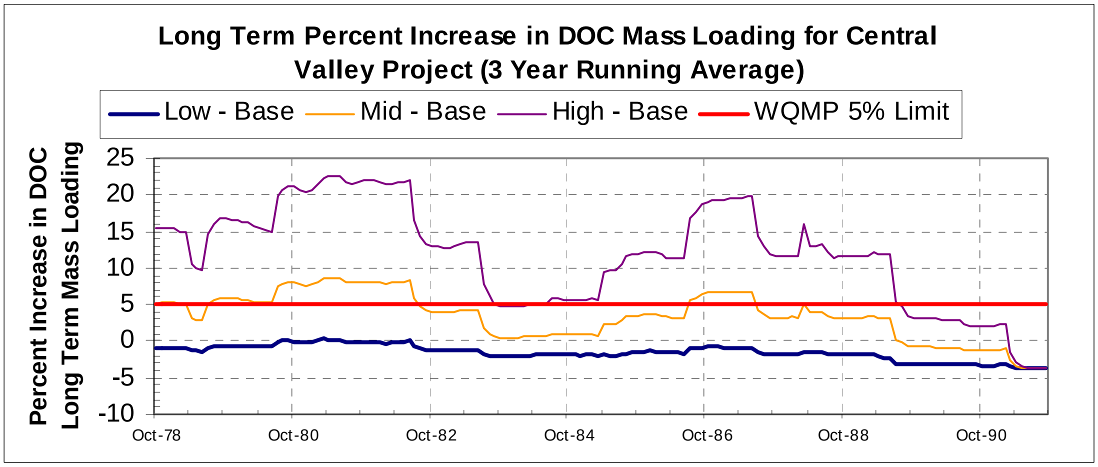

Figure 53: Percent Increase in Long Term DOC Mass Loading for Central Valley Project based on a 3-Year Running Average.

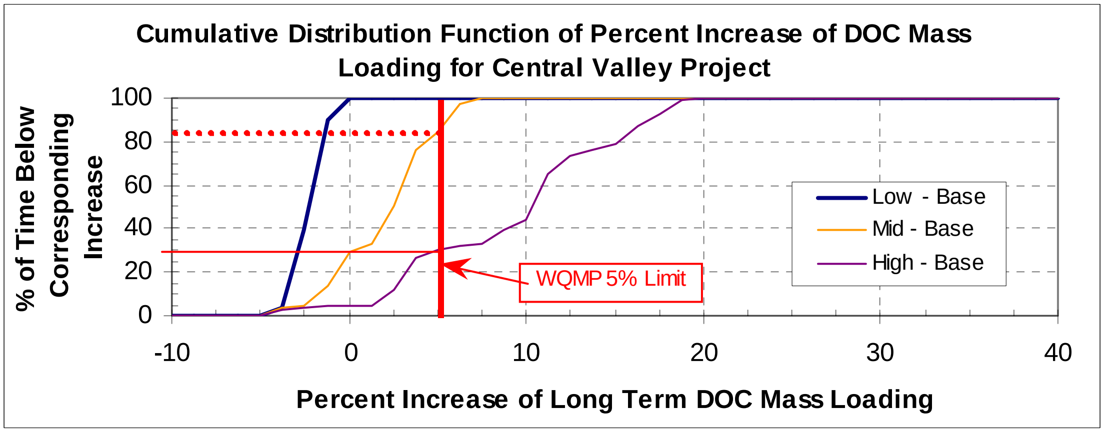

Figure 54: Cumulative Distribution Function of Percent Increase of Long Term DOC Mass Loading for Central Valley Project.

4.4. UVA

Three different UVA simulations were run to find UVA levels at the four urban water intakes due to the operation of the Delta Wetlands project that could later be used to compute TTHM (see Section 4.5). The level of the UVA releases for each of these bookend simulations is described above in Table 4 (see Section 2.2).

The UVA simulations were treated similar to the DOC simulations (see Section 4.2). The diversions into the reservoirs were treated as standard diversions. Water was removed from the Delta at the planned intake locations. Similarly, the releases from the islands were treated as rim or return flows at the planned discharge locations. Fixed UVA measurements were assigned to these releases. The UVA from these project island releases mixed with the already present in channel UVA.

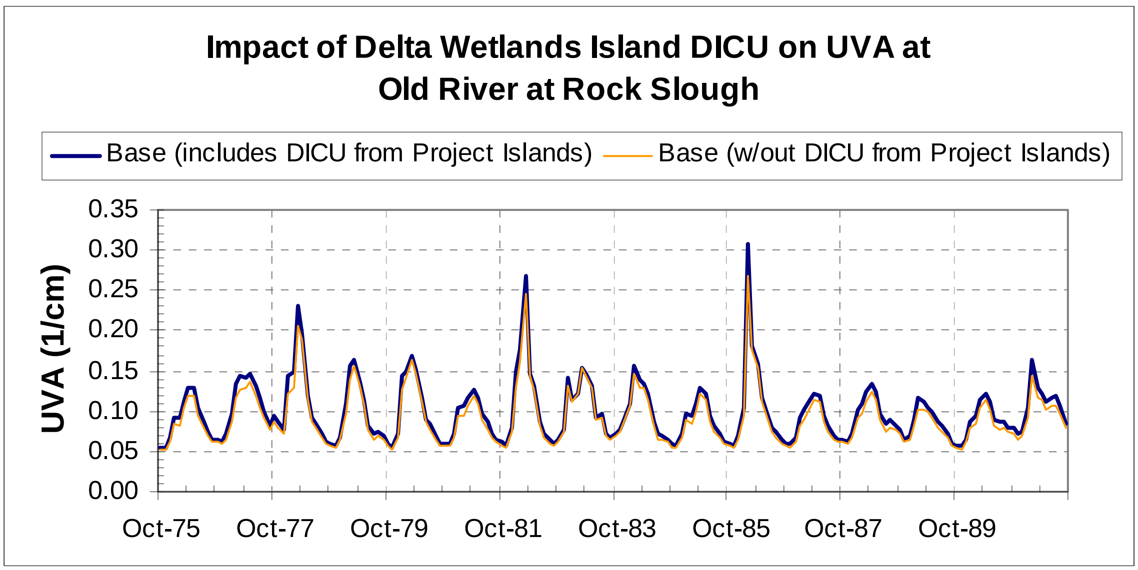

Figure 55: Effect of DICU around the Delta Wetlands Islands on Old River at Rock Slough.

As with the *DOC ag credit* (see Section 4.2) the benefit of changing the agricultural diversions and returns on the project islands at Rock Slough is shown above in Figure 55. This benefit, referred to as the *UVA ag credit*, was found to be relatively small at all four of the intake locations.

Figures 56, 58, 60, and 62 illustrate the sensitivity to UVA release measurements at each of the four urban intake locations: Old River at Rock Slough, Old River at the Los Vaqueros intake, the State Water Project intake at Banks Pumping Plant, and the Central Valley Project intake at Tracy. In the base case, the periods of high UVA for all of the locations coincided with the high runoff periods that start in the spring and sometimes continue through early summer. The summer releases from the project islands resulted in UVA measurement increases for all three bookend levels. At Rock Slough (see Figure 56), the process of releasing water during the summer at the mid and high bookend UVA values, effectively increased the number of times over the 16-year period that the UVA measurement at Rock Slough reached above 0.20 cm^{-1}. However, these higher measurements did not exceed the winter monthly maximum from the base case. At the other three intake locations, the summer project water did exceed the base case monthly maximum. Furthermore Los Vaqueros, the State Water Project, and the Central Valley Project were much more sensitive to UVA releases from the project islands. Rock Slough is located to the north of the Bacon Island discharge location, and given that the predominant flows on the Old River tend to be heading south, Bacon Island releases have less of an impact on Rock Slough.

The maximum monthly averaged UVA at these four locations over the entire 16-year planning study is summarized in Table 11. As shown in Figure 10, the monthly agricultural UVA measurements from all of the Delta islands range from around 0.25 to 1.60 cm^{-1}. For all three bookend simulations, the largest maximum monthly UVA measurements were observed at Los Vaqueros. The maximum monthly change in UVA measurement is shown in Table 12. Again the largest changes were observed at Los Vaqueros, which is closer to the project islands than the SWP and CVP intakes.

Table 11: Maximum monthly averaged UVA (cm^{-1}) measurements.

Location	*Base*	*Low (0.289 cm^{-1})*	*Mid (0.686 cm^{-1})*	*High (1.348 cm^{-1})*
Old River at Rock Slough	0.309	0.263	0.263	0.267
Old River at Los Vaqueros intake	0.308	0.296	0.461	0.848
State Water Project	0.189	0.187	0.311	0.517
Central Valley Project	0.182	0.182	0.286	0.467

Table 12: Maximum monthly change in UVA (cm^{-1}).

Location	*Low – Base*	*Mid - Base*	*High - Base*
Old River at Rock Slough	0.022	0.079	0.174
Old River at Los Vaqueros intake	0.078	0.310	0.698
State Water Project	0.043	0.162	0.368
Central Valley Project	0.043	0.146	0.323

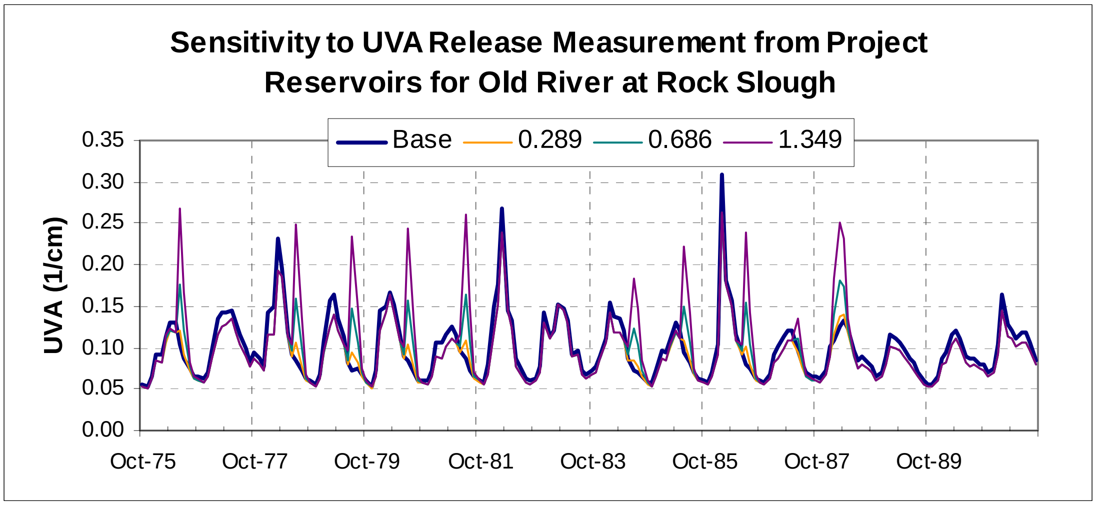

Figure 56: Time Series of UVA for Old River at Rock Slough.

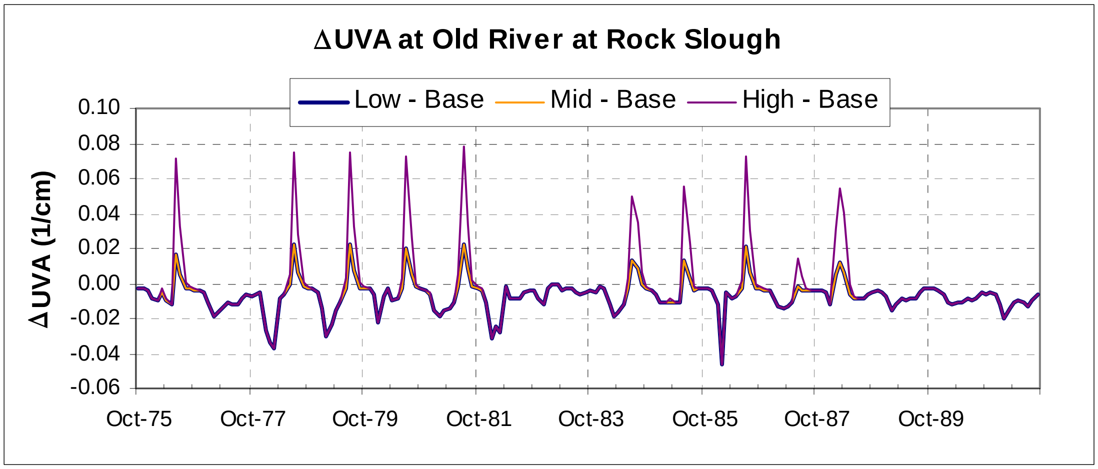

Figure 57: Time Series of Change in UVA (Alternative – Base) for Old River at Rock Slough.

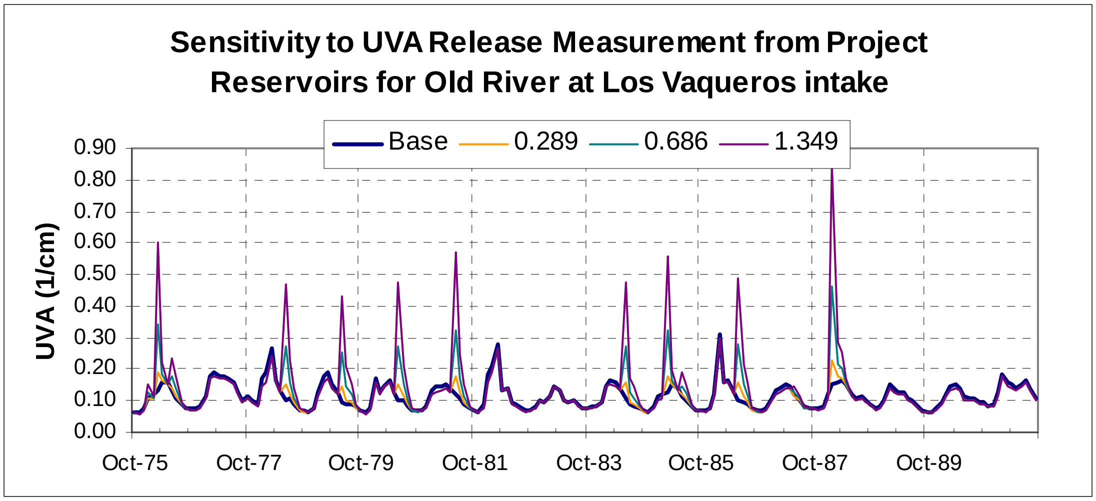

Figure 58: Time Series of UVA for Old River at Los Vaqueros intake.

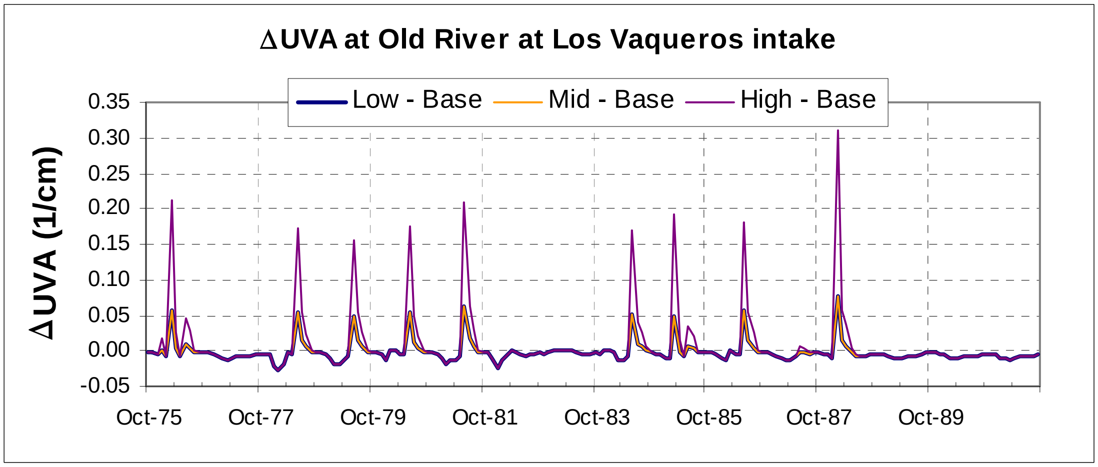

Figure 59: Time Series of Change in UVA (Alternative – Base) for Old River at Los Vaqueros intake.

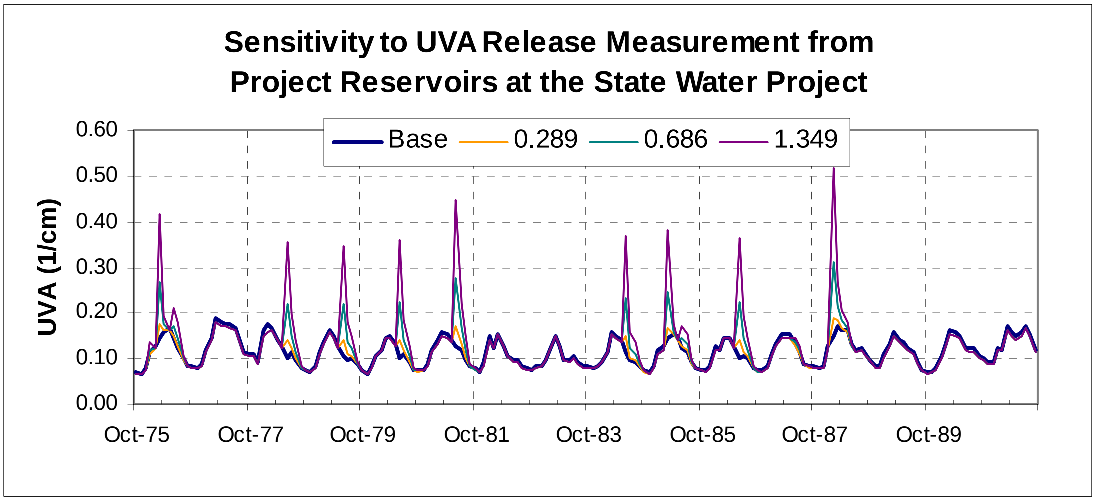

Figure 60: Time Series of UVA for the State Water Project.

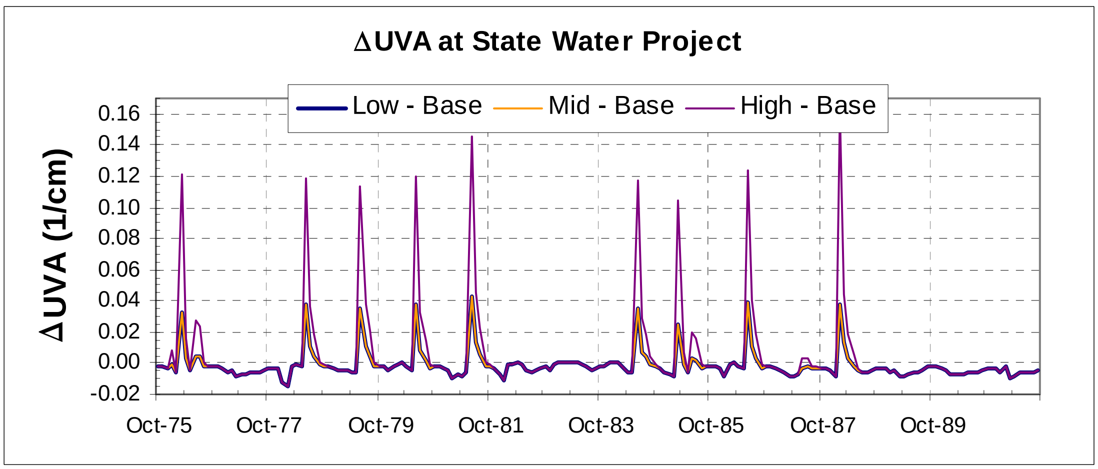

Figure 61: Time Series of Change in UVA (Alternative – Base) for the State Water Project.

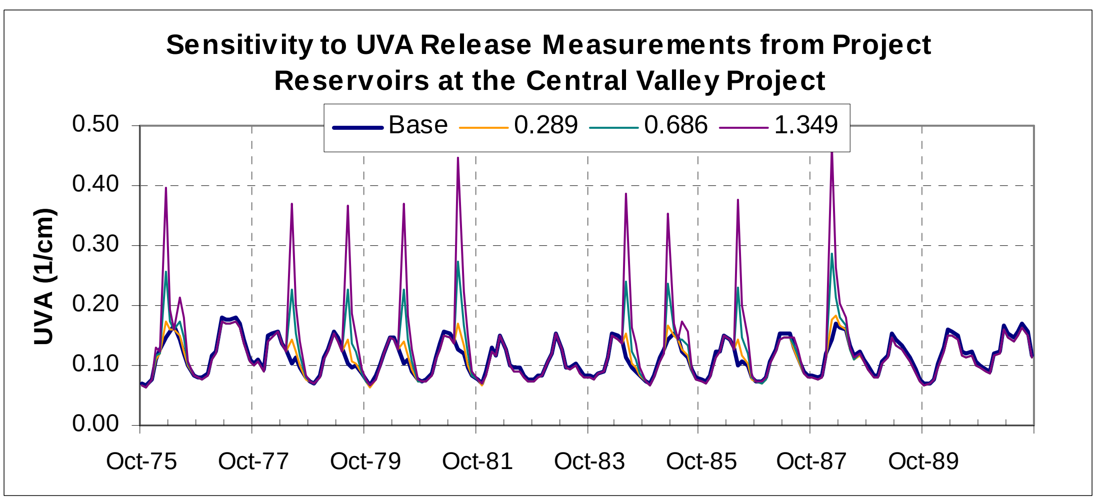

Figure 62: Time Series of UVA for the Central Valley Project.

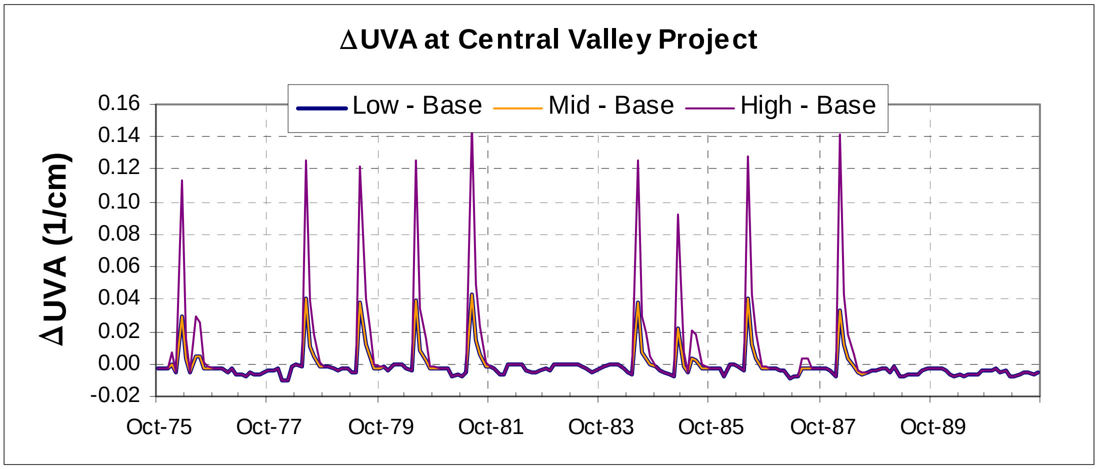

Figure 63: Time Series of Change in UVA (Alternative – Base) for the Central Valley Project.

4.5. TTHM

According to the WQMP Total Trihalomethane (TTHM) formation is limited 64 ug/l. For periods when the modeled base case exceeds this 64 ug/l standard, the WQMP permitted a 5% increase above the standard (3.2 ug/l) due to operation of the Delta Wetlands project.

Using the EC, DOC, and UVA results from each of the DSM2 bookend simulations, the TTHM for Old River at Rock Slough was calculated as:

$$TTHM = C_1 \times DOC^{0.228} \times UVA^{0.534} \times (Br+1)^{2.01} \times T^{0.48} \qquad \text{[Eqn. 5]}$$

where

TTHM = total trihalomethane concentration (ug/l),
C_1 = 14.5 when DOC < 4 mg/l,
C_1 = 12.5 when DOC ≥ 4 mg/l,
DOC = raw water dissolved organic carbon (mg/l) from DSM2,
UVA = raw water ultraviolet absorbance at 254 nm (1/cm) from DSM2,
Br = raw water bromide concentration (mg/l) as converted from DSM2, and
T = raw water temperature.

The bromide concentration at Rock Slough was developed by Bob Suits (2001) from regressions of observed (1) Contra Costa Canal Pumping Plant #1 Chloride data to Contra Costa Canal Pumping Plant #1 Bromide data, and (2) Contra Costa Canal Pumping Plant #1 Chloride data to Rock Slough EC. The bromide relationship used in Equation 5 for Rock Slough is:

$$Br_{Rock\,Slough} = \frac{EC_{Rock\,Slough} - 118.7}{1040.3} \qquad \text{[Eqn. 6]}$$

The bromide relationship for the remaining urban intake locations used in Equation 5 is:

$$Br = \frac{EC - 189.2}{1020.77} \qquad \text{[Eqn. 7]}$$

The monthly average water temperatures used in Equation 5 are shown below in Figure 64. These temperature data came from Contra Costa water treatment plant averages, as provided by K.T. Shum of Contra Costa Water District (Forkel, 2000b).

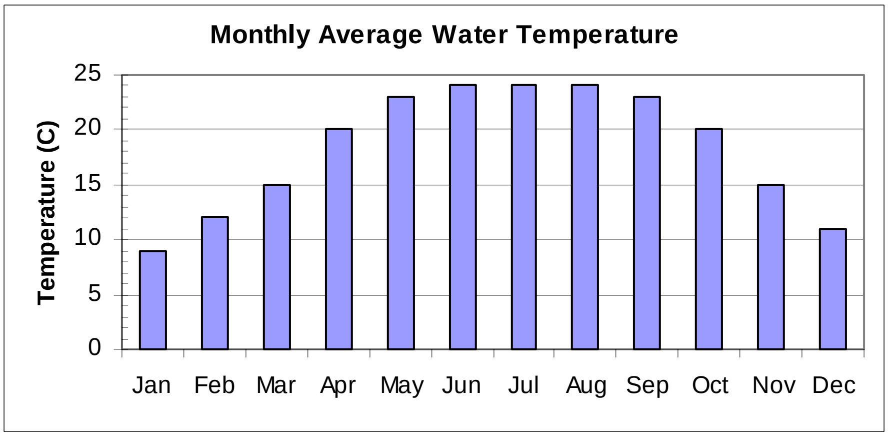

Figure 64: Monthly Average Water Temperature.

Using Equations 5, 6, and 7, the TTHM for all the urban intakes was calculated for the entire 16-year simulation period. The sensitivity to DOC release from the project islands is shown in Figures 65 – 72. The 64 ug/l WQMP standard is exceeded in the late fall and early winter months both in the base and alternative scenarios as is shown in Figures 65, 67, 69, and 71. This is consistent with the EC results discussed in Section 4.1, since bromide (which is directly related to EC) is a principal contributor to TTHM formation.

Table 13: Maximum monthly averaged TTHM (ug/l) concentrations.

Location	*Base*	*Low*	*Mid*	*High*
Old River at Rock Slough	131	124	124	124
Old River at Los Vaqueros	123	119	119	131
State Water Project	100	96	96	110
Central Valley Project	93	90	90	107

The maximum monthly TTHM concentrations for each of the simulations are displayed in Table 13. Since the EC and water temperature used to calculate the level of TTHM formation for each of the three bookend scenarios was the same, the differences in the TTHM concentrations is a function of the DOC and UVA values. For the Contra Costa intake at Old River at Rock Slough, the operation of the Delta Wetlands Project actually appears to decrease the maximum monthly TTHM concentrations. There was no significant difference between the three scenarios, but this is due to the fact that the DOC and UVA values at Rock Slough were very similar. For the other three intake locations, the high DOC and UVA release scenario results in increases in the maximum monthly

TTHM concentrations, while the other two scenarios result in slight decreases. It is important to remember that the majority of the releases from the project islands occur in the summer, and thus Table 13 does not provide a good estimate of the year round impact of the operation of the Delta Wetlands Project.

Time series plots (see Figures 66, 68, 70, and 72) illustrating the change between each alternative scenario and the base case provide a more useful tool to assess the impact of the project operation on TTHM formation. Although these plots show the change due to project operation over the entire simulation period, the intermittent 3.2 ug/l maximum increase in TTHM standard applies only at the times when the regular 64 ug/l standard was exceeded by the base case as shown in Figures 65, 67, 69, and 71. Even though releases from the project islands resulted in significant increases in TTHM at all four urban intake locations, typically these increases did not exceed the 64 ug/l standard, and thus according to the WQMP should not be constrained by the 3.2 ug/l maximum increase standard.

The largest increase in TTHM occurred in the summer of 1988 at the Los Vaqueros Reservoir intake location for both the mid and high levels of DOC release (see Figure 68). However, both of these increases exceeded 64 ug/l at a time when the base case was below the standard (see Figure 67). The maximum monthly increase in TTHM at the urban intake locations for only those times when the base case scenario exceeded the 64 ug/l standard is listed below in Table 14. Based on Table 14, there appears to be little difference between the scenarios. The only location where TTHM increased due to project operation was at Old River at Rock Slough.

Table 14: Maximum monthly increase in TTHM (ug/l) when base scenario was greater than the WQMP 64 ug/l standard.

Location	***Low – Base***	***Mid - Base***	***High - Base***
Old River at Rock Slough	4.39	4.40	4.40
Old River at Los Vaqueros intake	-1.42	-1.42	-1.29
State Water Project	-0.63	-0.63	-0.63
Central Valley Project	-0.58	-0.58	-0.58

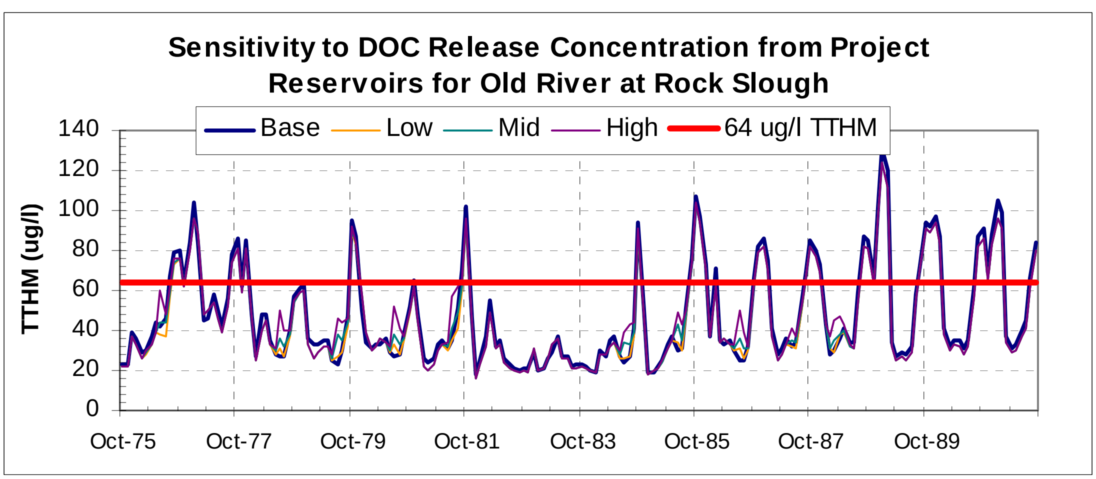

Figure 65: Time Series of TTHM Formation for Old River at Rock Slough.

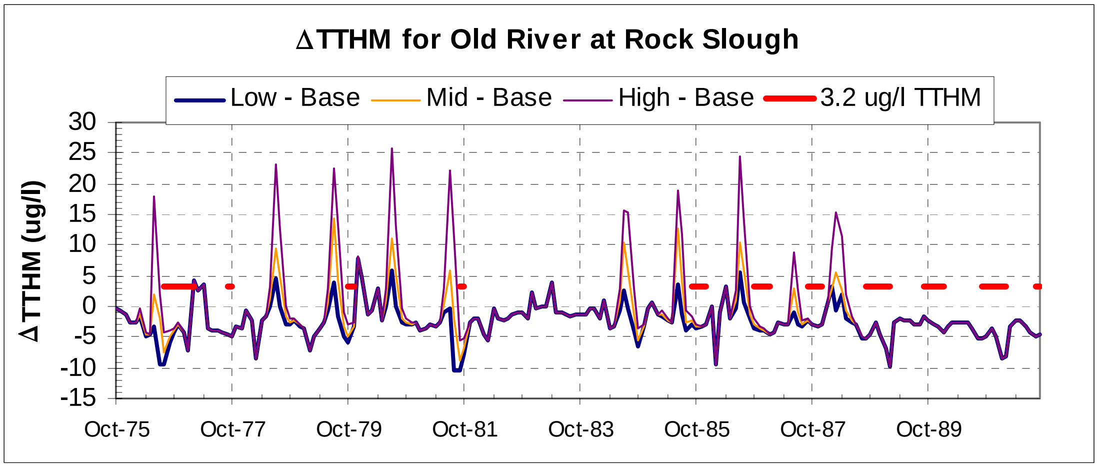

Figure 66: Time Series of Change in TTHM (Alternative – Base) for Old River at Rock Slough.

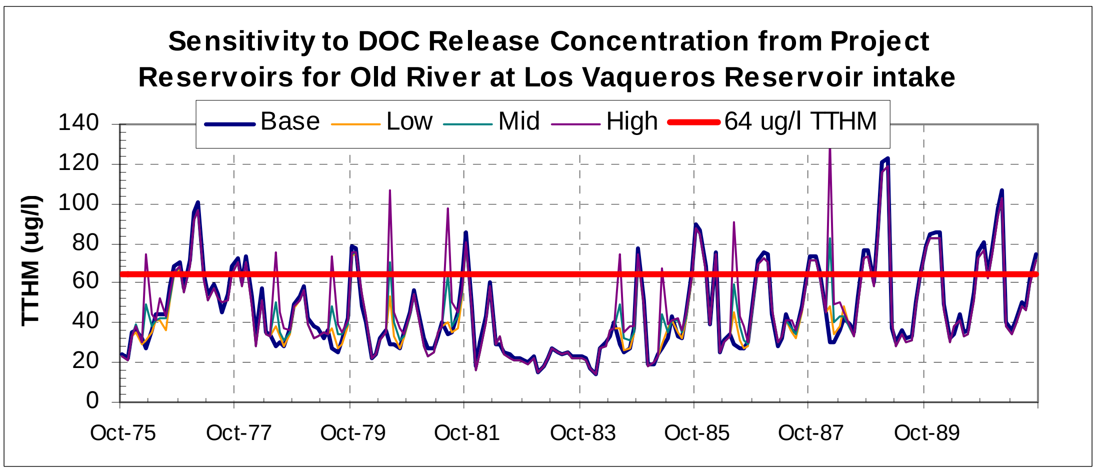

Figure 67: Time Series of TTHM Formation for Old River at Los Vaqueros intake.

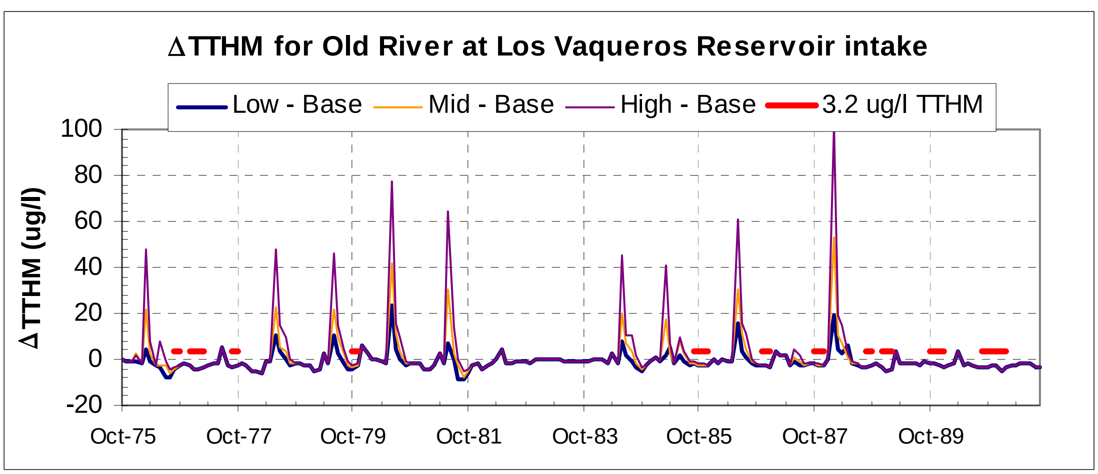

Figure 68: Time Series of Change in TTHM (Alternative – Base) for Old River at Los Vaqueros intake.

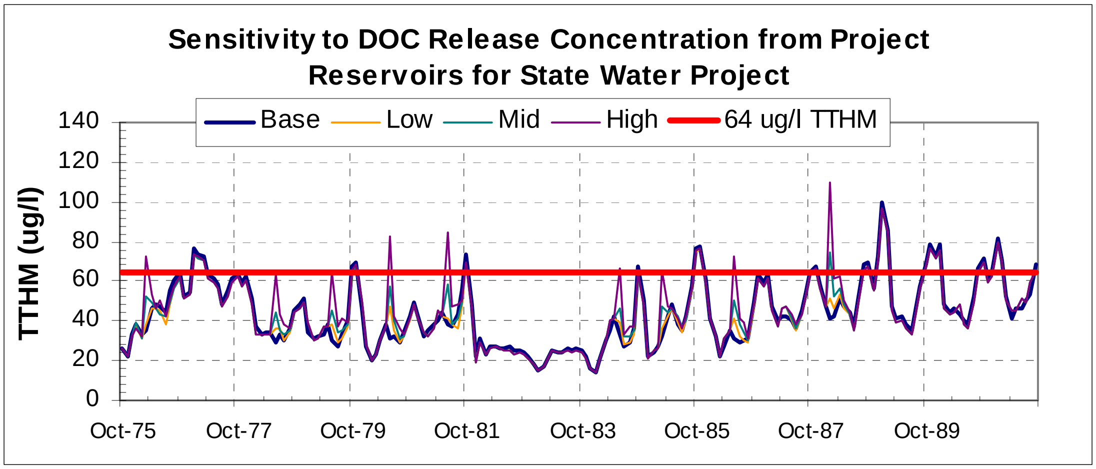

Figure 69: Time Series of TTHM Formation for State Water Project.

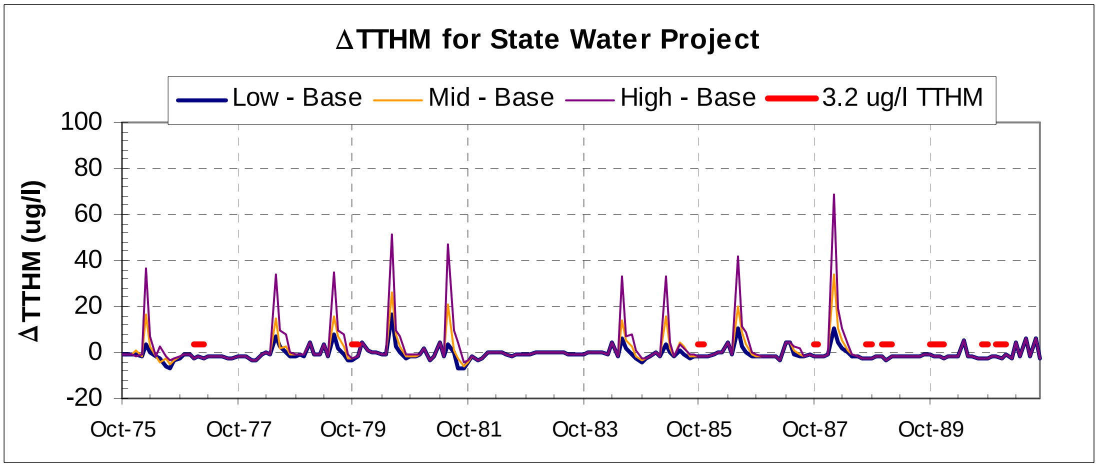

Figure 70: Time Series of Change in TTHM (Alternative – Base) for State Water Project.

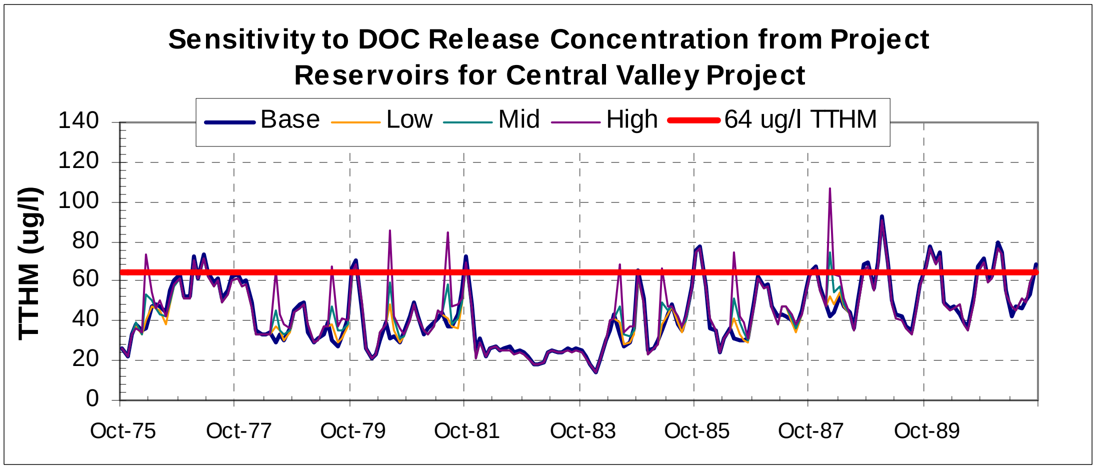

Figure 71: Time Series of TTHM Formation for State Water Project.

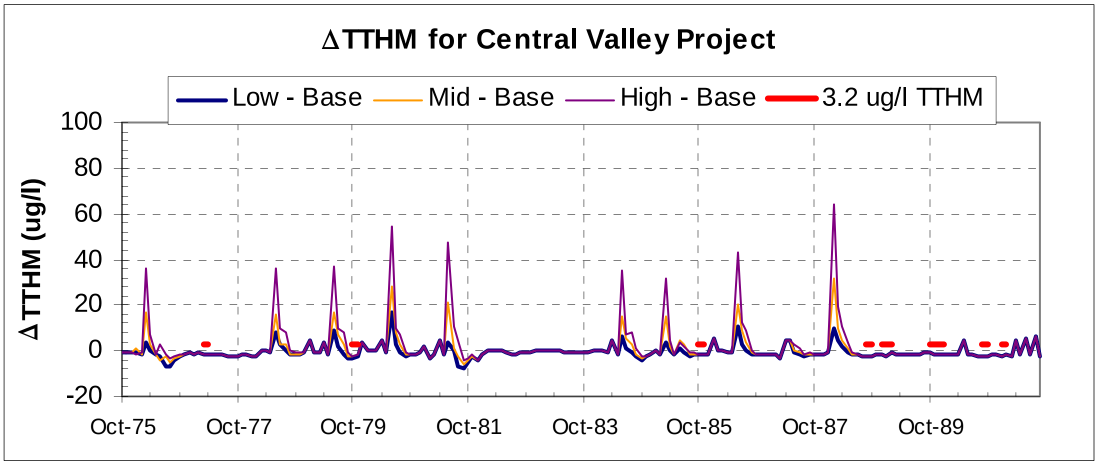

Figure 72: Time Series of Change in TTHM (Alternative – Base) for Central Valley Project.

4.6. Bromate (BRM)

According to the WQMP Bromate formation is limited 8 ug/l. For periods when the modeled base case exceeds this 8 ug/l standard, the WQMP permitted a 5% increase above the standard (0.4 ug/l) due to operation of the Delta Wetlands project.

Using EC and DOC for each of the DSM2 bookend simulations, bromate for Old River at Rock Slough was calculated as:

$$BRM = C_2 \times DOC^{0.31} \times Br^{0.73} \quad \text{[Eqn. 8]}$$

where

BRM = bromate (ug/l),
C_2 = 9.6 when DOC < 4 mg/l,
C_2 = 9.2 when DOC ≥ 4 mg/l,
DOC = raw water dissolved organic carbon (mg/l) from DSM2, and
Br = raw water bromide from Equations 5 and 6.

Using Equations 6, 7, and 8, the bromate for all the urban intakes was calculated for the entire 16-year simulation period. The sensitivity to DOC release from the project islands is shown in Figures 73 – 80. Though bromate formation is a function of both DOC and bromide concentration, the bromide concentrations used to calculate bromate for each of the three DOC concentration levels were the same. The only differences between the three alternative scenarios occurred when water was released from the project islands, which typically occurred in the summer months (see Figure 2). As shown in Figures 73, 75, 77, and 79, the modeled base case bromate concentrations at all four intakes frequently exceeded the 8 ug/l WQMP standard during these release periods.

The maximum monthly bromate concentrations for each of the simulations are displayed in Table 15. For all four intake locations the operation of the project did not increase the maximum monthly bromate concentration. However, it is important to remember that there are still increases associated with the summer releases discussed above, thus the usefulness of this absolute time series plots and monthly maximum values are limited.

Table 15: Maximum monthly averaged bromate (ug/l) concentrations.

Location	***Base***	***Low***	***Mid***	***High***
Old River at Rock Slough	22.14	21.83	21.83	21.83
Old River at Los Vaqueros	20.54	20.26	2026	20.26
State Water Project	18.26	18.07	18.07	18.07
Central Valley Project	17.62	17.46	17.46	17.46

Time series plots (see Figures 74, 76, 78, and 80) illustrating the change between each alternative scenario and the base case provide a more useful tool to assess the impact of the project operation on bromate formation. Although these plots show the change due to project operation over the entire simulation period, the intermittent 0.4 ug/l maximum increase in bromate standard applies only at the times when the regular 8 ug/l WQMP standard was exceeded by the base case as discussed above. The maximum monthly increase in bromate when this second WQMP standard controls is listed in Table 16.

The bromate concentration at all four intake locations exceeded the WQMP 0.4 ug/l maximum increase standard several times due to the project operation. As listed in Table 16, the largest increase occurred at the Old River at Rock Slough intake location in December 1979. It is important to note that during this month water was diverted to the project islands (see Figure 1) which resulted in salinity in the a difference in salinity of over 200 umhos/cm between the alternative scenarios and the base case (see Figure 17). Increases in bromate concentration at Rock Slough also occurred in the winters of 1985, 1986, and 1988, all of which correspond with both periods of high salinity intrusion into the Central Delta and diversions into one or both of the project islands.

Table 16: Maximum monthly increase in bromate (ug/l) when base scenario was greater than the WQMP 8 ug/l standard.

Location	***Low – Base***	***Mid - Base***	***High - Base***
Old River at Rock Slough	1.69	1.69	1.69
Old River at Los Vaqueros intake	1.36	1.36	1.37
State Water Project	1.02	1.02	1.03
Central Valley Project	0.97	0.97	0.97

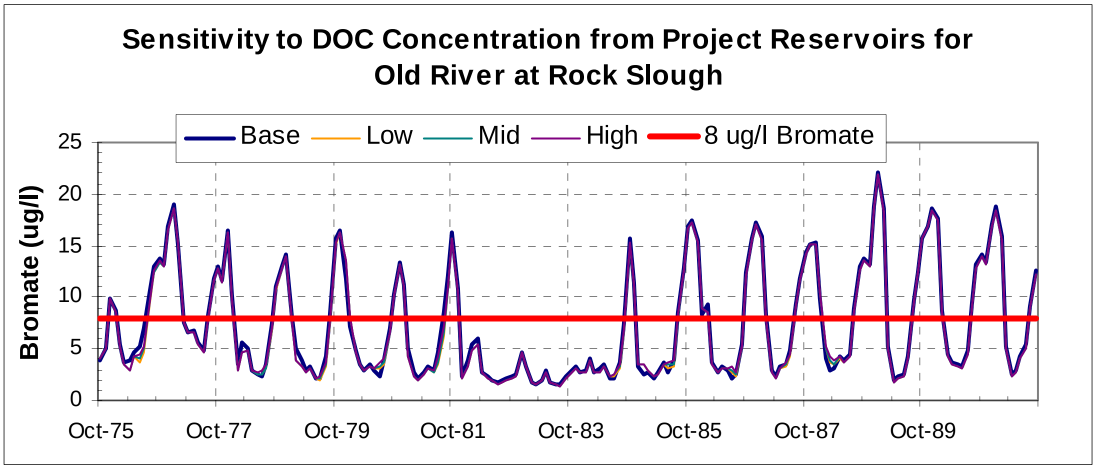

Figure 73: Time Series of Bromate Formation for Old River at Rock Slough.

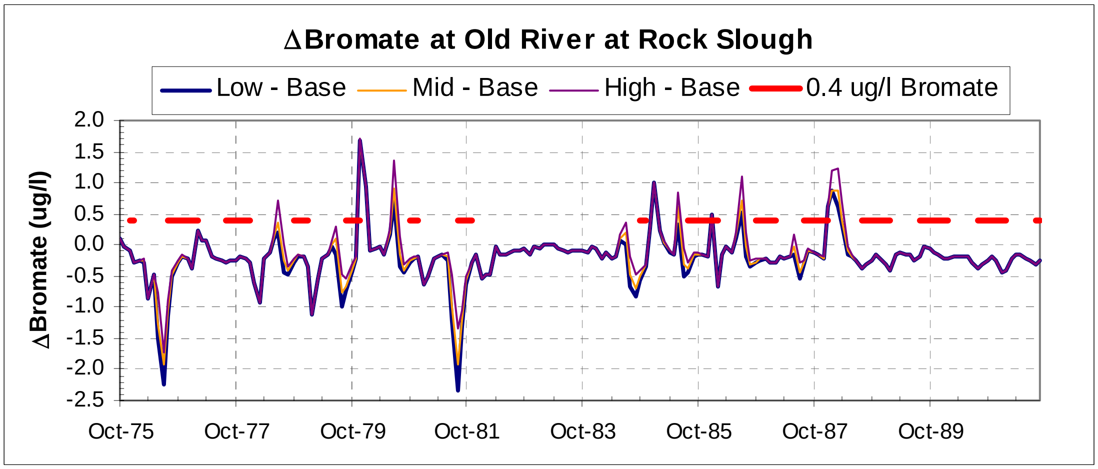

Figure 74: Time Series of Change in Bromate (Alternative – Base) for Old River at Rock Slough.

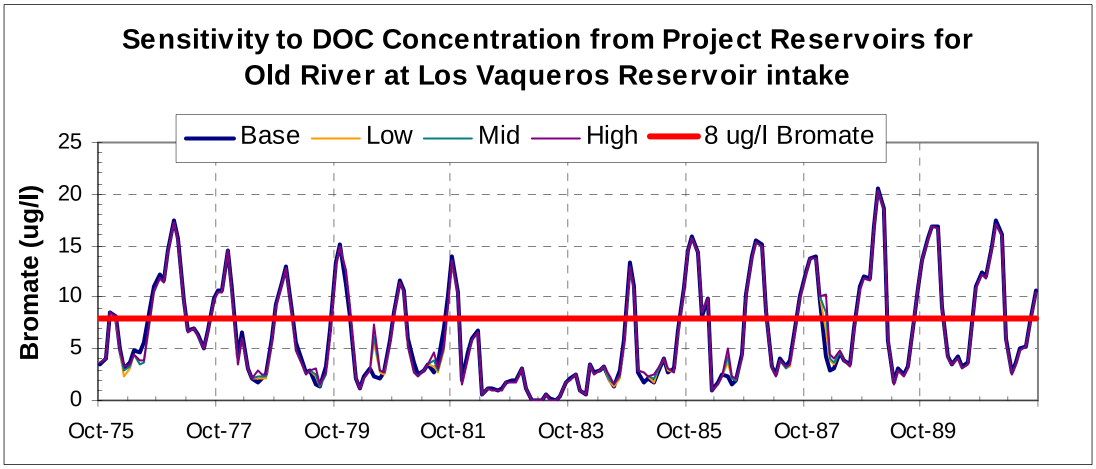

Figure 75: Time Series of Bromate Formation for Old River at Los Vaqueros intake.

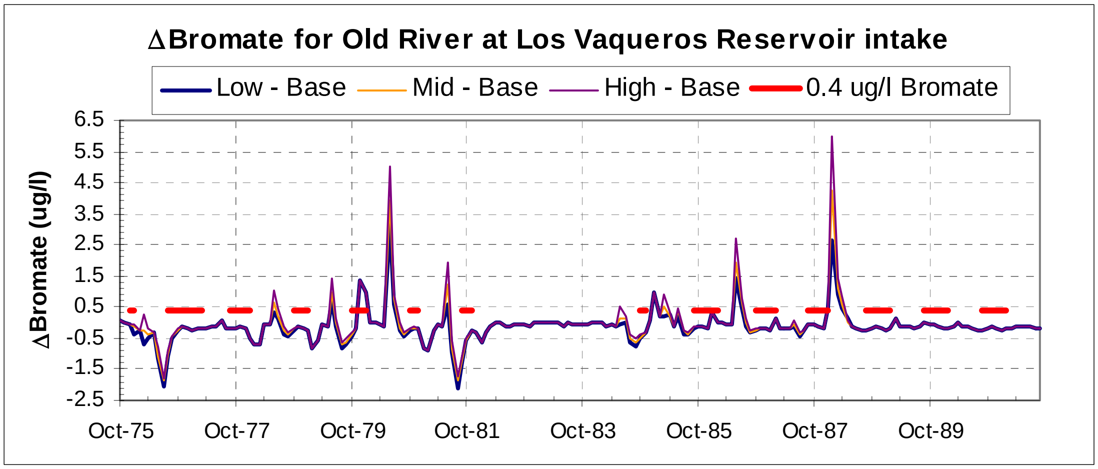

Figure 76: Time Series of Change in Bromate (Alternative – Base) for Old River at Los Vaqueros intake.

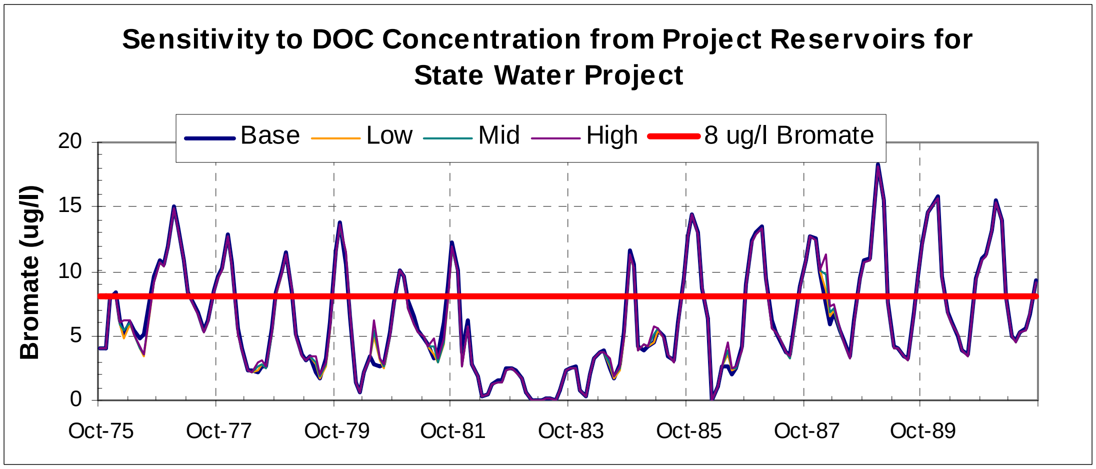

Figure 77: Time Series of Bromate Formation for State Water Project.

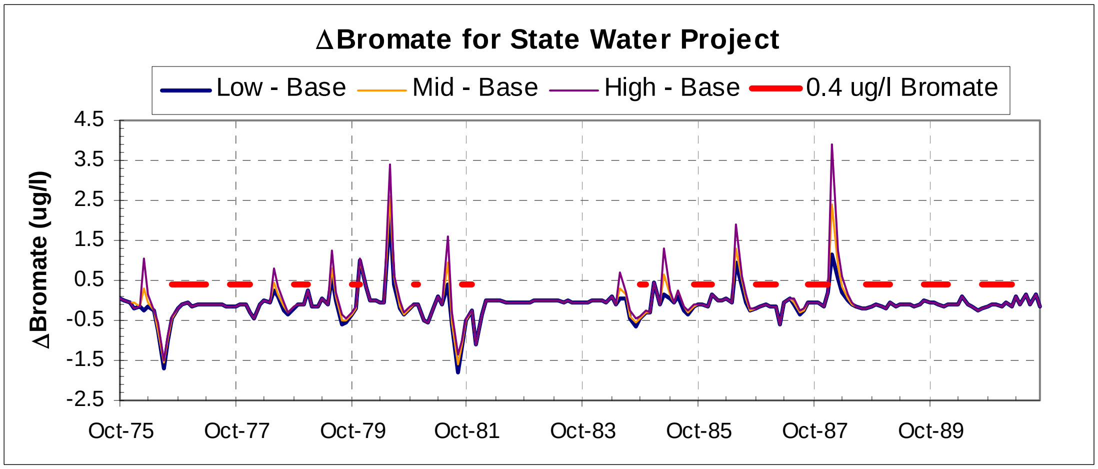

Figure 78: Time Series of Change in Bromate (Alternative – Base) for State Water Project.

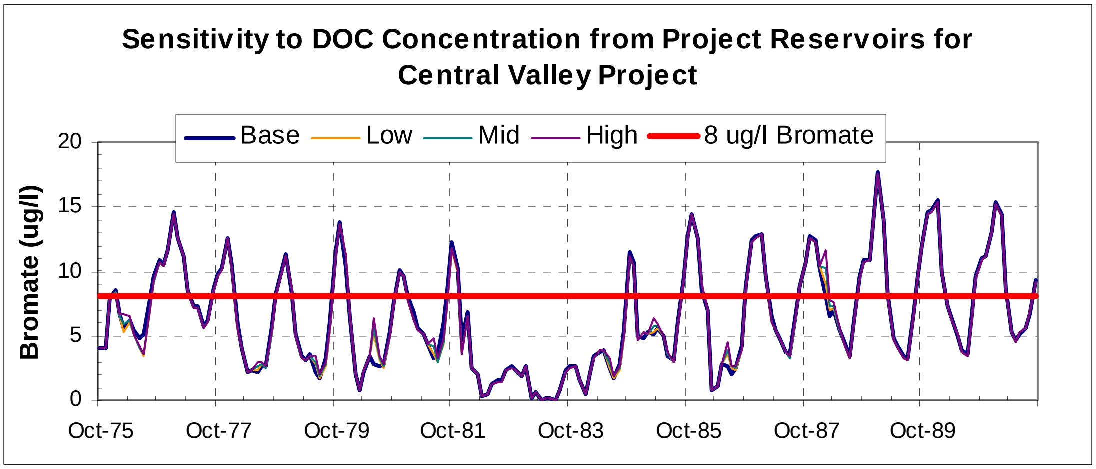

Figure 79: Time Series of Bromate Formation for Central Valley Project.

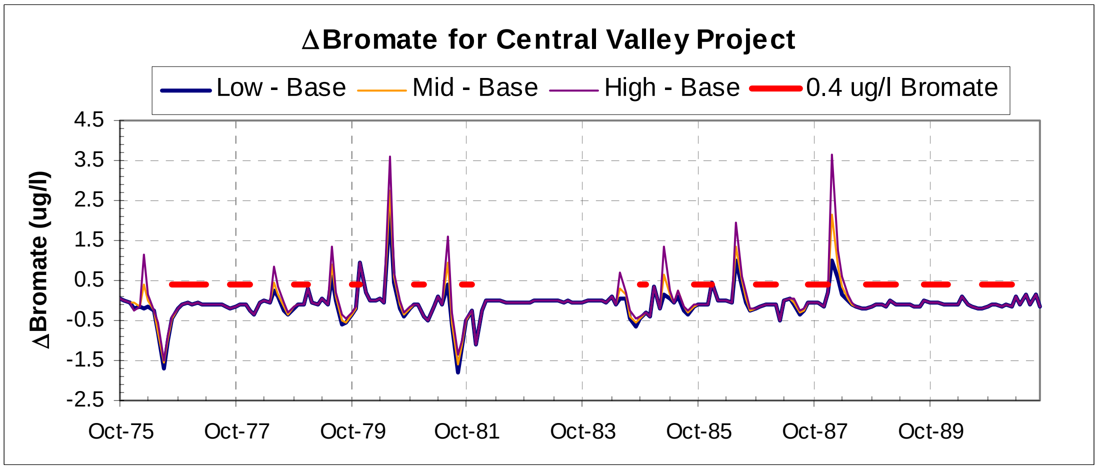

Figure 80: Time Series of Change in Bromate (Alternative – Base) for Central Valley Project.

5. Conclusions

- The DWRSIM 771 base case hydrology exceeded the Rock Slough Chloride standard nearly every winter during the 16-year simulation period with the exception of 1982 and 1983. Therefore the modeled EC at the four urban intakes is suspect for the Delta Wetlands alternative. It is recommended that a more accurate base case hydrology be used in future DSM2 studies.

- There was little difference in modeled EC between the base and Delta Wetlands alternative. The EC concentration of the water released from the project islands is a function of the quality of the water diverted on to the islands. Since TTHM and BRM formation are highly dependent on bromide concentration (which was calculated using EC), care must be taken when diverting water into the project islands in order to manage the EC, TTHM, and BRM impacts of the project islands.

- DSM2 simulated the project islands releases using three fixed concentrations at the discharge locations. QUAL did not consider the residence time of the water stored in the project islands. For future studies QUAL will be modified in order to better simulate the impact of storing water in the project islands for extended periods.

- The benefit of reducing the return of water from Bacon Island and Webb Tract on DOC, referred to as the *DOC ag credit*, ranged between 0 – 0.3 mg/l for Old River at Rock Slough. This *DOC ag credit* was less significant at the other three intake locations.

- The DSM2 DOC base case frequently exceeded the 4 mg/l DOC standard at all four intake locations during the late winter runoff periods.

- The mid- and high- DOC concentration releases from the project islands (which typically occurred in the summer) exceeded the 4 mg/l DOC standard. The increased DOC observed in DSM2 at the intakes ranged from around 3 – 4 mg/l at Rock Slough to an 8 mg/l increase at the Los Vaqueros intake on the Old River.

- Though the low DOC concentration release from the project islands did not exceed the 1 mg/l increase standard stipulated by the Delta Wetlands WQMP, this 6 mg/l DOC release approached the standard at the Los Vaqueros intake on the Old River.

- The long-term DOC trend (based on 3 year running averages) consistently showed the low-DOC concentration release scenarios to decrease the DOC mass loading at all four urban intakes. The mid- and high-DOC concentration release scenarios all exceeded the WQMP 5% increase in DOC mass loading limit.

- Los Vaqueros is the most sensitive intake location for both short- and long-term DOC. Future studies will model the discharge location for Bacon Island further to the east along the Middle River, which may reduce the DOC loading at Los Vaqueros due to project releases.

- UVA showed trends similar to those discussed above for DOC. The *UVA ag credit* was relatively small at all of the intake locations (less than 0.02 1/cm). Los Vaqueros is the most sensitive intake location. However, UVA is a factor in TTHM formation, thus it should still be modeled in future DSM2 simulations.

- The DWRSIM 771 hydrology, which was used as input for HYDRO, did not separate the diversions / exports between Contra Costa's Old River at Rock Slough intake and its' Los Vaqueros intake. The intake also lies between Bacon Island and the SWP and CVP intakes on the Old River. Even without modeling any exports from this location, the Los Vaqueros intake showed the most sensitivity to both DOC and UVA. For future studies it is recommended that operating rules be devised so that CALSIM can represent the diversions / exports at the Los Vaqueros intake.

- Since TTHM and BRM formation is highly dependent upon bromide, and even in the base case the Rock Slough chloride standard was exceeded, the TTHM and BRM calculated concentrations are suspect. When DSM2 is run again with improved operating conditions, TTHM and BRM relationships for the other intake locations will be developed and the formation of TTHM and BRM at all the intake locations will be revisited.

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